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THE JAMAICA EARTHQUAKE[1]

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WITHIN nine months three regions in the western hemisphere, geologically closely akin but geographically distant one from the other, have been visited by earthquakes, causing an appalling loss of life and property. In all cases the disasters have been preceded by minor earth-shakings for years, and the areas were known to be in zones of earth-unrest. No warning, however, unless the tremors that occur at irregular intervals every month or two could be counted as such, has characterized these last disturbances. But these tremors must be regarded as the climax of a long-continued yielding to strain which has resulted in a series of minor breakings. This faulting culminated in a great fracturing of the earth's crust and a consequent destructive earth-shaking. The kindred conditions of these different areas appear to be, first, a considerable amount of differential relief only obtained where mountains are associated with marine depths; and, in the second place, where newer and less compacted sediments occur upon these slopes.

For several months previous to the afternoon of January 14, 1907, there had been no noticeable increase in the number or intensity of the customary slight shocks that occur in the Island of Jamaica every month or two. In Weather Report IV. of Jamaica, Mr. Maxwell Hall

[1] The writer desires to acknowledge his indebtedness to Dr. Charles D. Walcott, formerly director of the U. S. Geological Survey, and to J. D'Aeth, assistant director of Public Works; Mr. Maxwell Hall, resident magistrate; Mr. Charlton Thompson, harbor master, and to many other official and private citizens of Jamaica for their cordial cooperation and aid in the prosecution of the investigation.

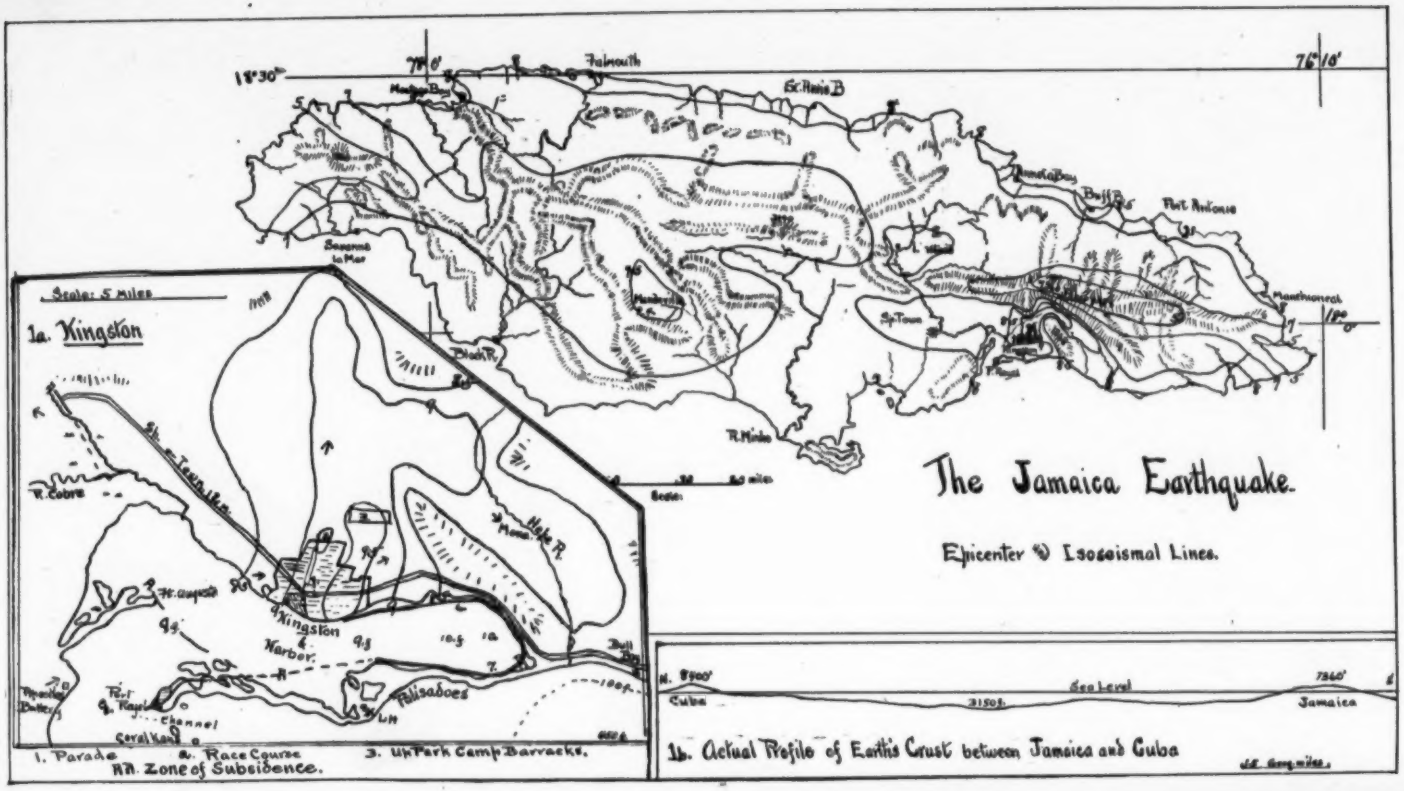
18°30'
77°0'
76°10'
Falmouth
St. Ann's B.
Montego Bay
Port Antonio
Spanish Town
Kingston
Black R.
R. Minho
Scale: 5 miles
1a. Kingston
Hope R.
Port Royal
Palisadoes
Harbor
Channel
Coral Keys
1. Parade 2. Race Course 3. Up Park Camp Barracks.
RR Zone of Subsidence.
The Jamaica Earthquake.
Epicenter & Isoseismal Lines.
N. 8900'
Sea Level
7340'
Cuba
31505
Jamaica
1b. Actual Profile of Earth's Crust between Jamaica and Cuba

FIG. 2. PHOTOGRAPH OF COMD'R BARTLETT'S RELIEF MAP OF THE CARIBBEAN SEA.

has noted some twenty-six minor shocks that occurred from 1880 to 1886, and this number might be regarded as typical of the seismic phenomena in that region. A slight shock was noticed by many in November last, but the memories of the destruction of Port Royal by the historic earthquake of 1692 had been dulled by the interval of two centuries, and the Jamaicans had begun to think themselves in a region of comparative safety. Slight tremors and shocks caused but scant attention or notice on the part of a few of the people. Consequently, when the real cry of 'wolf' came, for the first second or so but few realized the danger. The slight tremor, however, instantly increased to a terrible vibration of the earth that threw down great walls and buildings and inside of a minute transformed the city of Kingston from a prosperous metropolis to a place of destruction and mourning.

In order to appreciate their relative importance and possible influence upon seismic activity, let us notice the topographic, geologic and bathographic conditions that exist at Jamaica.

The etymology of the word Jamaica, originating in two descriptive Indian words meaning 'well wooded and watered' and modified by the Spaniards to 'Xaymaca,'[2] is interesting, taken in connection with the historic topographic description of the island given by Columbus to Queen Isabella on his return from the West Indies—'a crumpled handkerchief picked up by the middle.'

The aptness of the simile can not be questioned when one sees the many steep knife-edged divides (typical 'bad-land' topography) rising abruptly in fifteen miles 7,400 feet to the misty Blue Mountain peaks that tower above the small inland valleys or the narrow plains that

[2] 'Handbook of Jamaica,' 1906, p. 23.

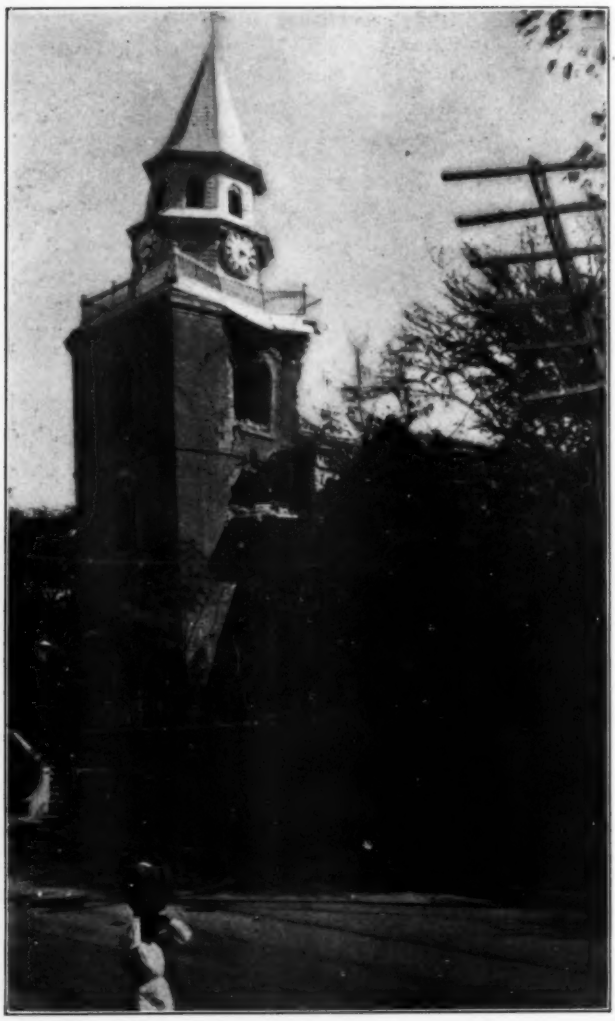

FIG. 3. TOWER OF PARISH CHURCH SHATTERED AND INCLINED TO THE EAST. Stopping of clock by shock.

fringe the seashore. These plains constitute the very small percentage of the island that is fairly level, and it is upon these plains that the larger towns and the larger plantations of bananas and sugar-cane are found. These level areas are made up of alluvial deposits, fans or sheet-wash brought from the adjacent ragged slopes by the rivers in flood time. Upon the rather bare slopes, occasional rectangular patches of light green show the location of small banana farms or 'pens.' But the more abundant and typical tropical verdure is found lower down on the fringing plains. The island has long been known for the abun-

dance and variety of its tropical and subtropical products, due to the fertility of the limestone soil and the abundance of the rainfall, which varies largely, however, in the amount, from 10 inches at Port Royal to 126 inches some years in the higher regions.

Geologically, Jamaica is of comparatively recent age,[3] for its basal Blue Mountain series of sediments and intrusives is of late Cretaceous and Eocene times. This series makes up the mountainous backbone of the island, while the later Oligocene limestone overlaps the former series in a thick piedmontal formation covering two thirds of the island. The more recent alluvial and littoral formations were deposited during the period of uniform elevation following, and constitute the fringing plains of the island.

In the structural geology of Jamaica, the earliest axis of folding now evident is the northwest-southeast line of the Blue Mountains, with later east-west foldings along the more ancient line of orogenic movement which outlined the Greater Antilles in early Mesozoic times.[4] The writer has observed transverse faults in the Blue Mountain region, which undoubtedly indicate lines along which fracture may occur.

M. de Ballore[5] coincides with Mr. Hill's ideas regarding an east-west folding for the Antilles in postulating his theory of an anticlinal axis that marks the line of the Greater Antilles and a parallel synclinal belt immediately to the north of Jamaica, which coincides with the Bartlett Deep. In the photograph of a relief map (Fig. 2), the east-west elevation and depression are brought out strongly.

The bathographic relations of Jamaica are significant. We see that Jamaica and the other Antillean islands are but the higher peaks of a lofty and precipitous, but submerged, mountain chain. The tremendous differential relief of over 38,000 feet that exists in places in the Caribbean region apparently coincides with a zone of seismic and volcanic frequency. We know that the crust of the earth is always in a state of tension. This stress may come from the shrinkage of the earth, from the loading or unloading of the earth's surface through erosion or deposition, or from other sources. The resistance is lessened on a relatively steep slope (Fig. 1, *b*) where the points of application of this lateral pressure at the ends, not falling in the same plane, tend to produce a fracture. When a sudden slip in the adjustment occurs, the resulting jar is transmitted through the earth as earthquake waves.

Port Royal is at the western tip of a narrow seven-mile sand-spit that makes a natural breakwater to one of the finest harbors in the

[3] 'The Geology and Physical Geography of Jamaica: a study of a type of Antillean development,' Robert T. Hill, *Bull. Mus. Comp. Zool.*, Vol. XXXIV., Geol. Series, Vol. IV., September, 1899, p. 421.

[4] *Ibid.*, p. 164.

[5] 'Tremblements de Terre,' F. de Montessus de Ballore, 1906, Fig. 63.

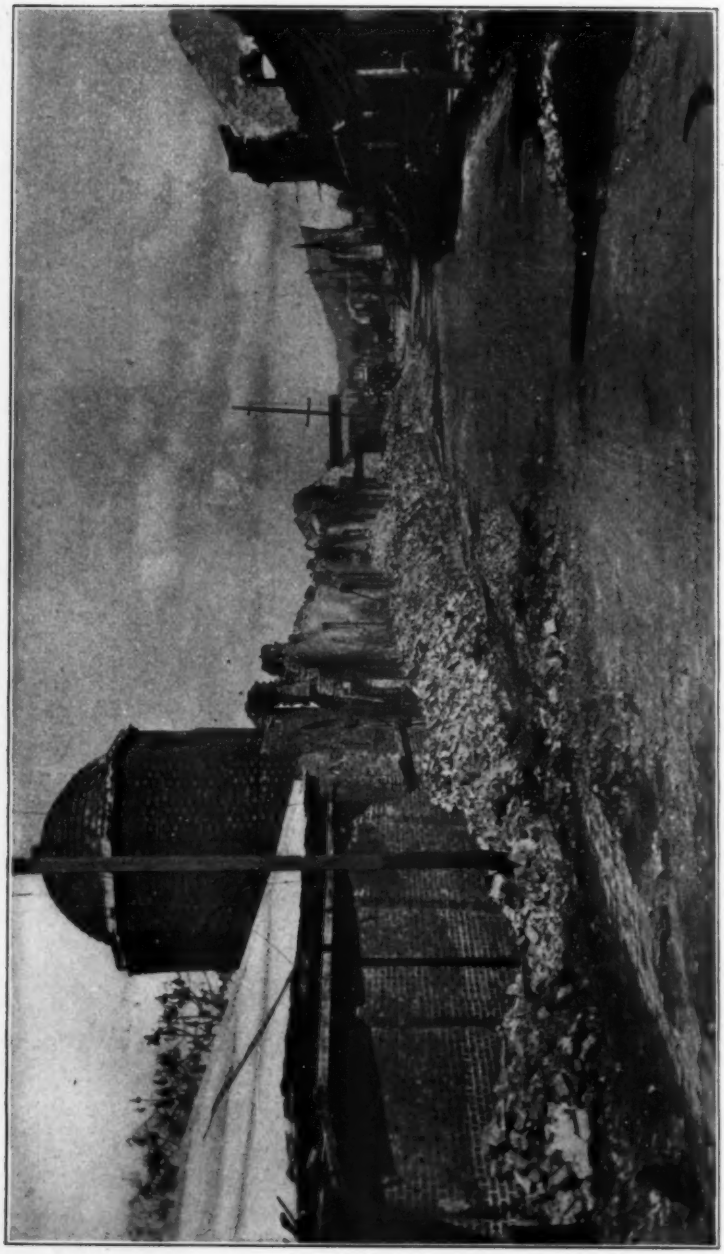

FIG. 4. STREET IN BUSINESS SECTION LOOKING NORTH. Western sidewalks covered with débris. Crack in fireproof, octagon building, showing angle of emergence of waves.

West Indies. When the town was for the most part submerged by the earthquake of 1692, this favorite site was abandoned for the Liguanea plain just across the harbor, and Kingston was founded on the largest of the fringing plains of loosely compacted sands and gravels. And here in this closely built city of 60,000 (and at Buff Bay opposite on the north shore) the destruction by the last earthquake was felt most keenly. Eighty-five per cent. of the buildings were injured or destroyed. Then came Kingston's old enemy, fire, and swept over ten or fifteen blocks of the business and warehouse section. (Figs. 4 and 5.)

The earthquake shock that brought disaster to the island of Jamaica began, according to the regulator of Mr. J. A. Soulette, at 3:33 P.M. Others record its arrival two or three minutes earlier. In various

FIG. 5. IN BURNED DISTRICT; THE NARROW HARBOUR STREET, looking east.

places on the island, as reported by local times, its occurrence varied from 3:20 to 3:45 P.M. In the investigation it was found impossible to plot any coseismal lines, for the reason that no accurate coordinated time exists in the island. Since the shock, however, there has been a movement on foot in Kingston to establish a system of accurate time-keeping throughout Jamaica. The shock lasted about thirty-five seconds, varying in length with the location and geological position of the observer. At the east end of the island some noted a duration of sixty seconds; on the north shore a length of ninety seconds, while at other points near by the duration reported was anywhere from five to forty seconds. The slight preliminary tremors were felt immediately before the main shock, and the noise and roar was heard slightly before the coming of the major vibrations. One man, used to earthquake

FIG. 6. LOOKING NORTH IN GENERAL PENITENTIARY BRICK-YARD. Upper third of brick chimney, upper part of smokestack (to guys), and upper ring of lime-kiln; together with large part of the brick wall thrown to the east. Fissures made in ground in lower part of view.

countries, hearing the sound from the preliminary tremors, rushed out-of-doors into the street only to be thrown down toward the west by the violent shaking. He dragged an injured companion a hundred feet or so during the slight lessening of the violent shock, and then felt the second climax of a slow undulating character pass underneath. This experience is like the phenomena of double earthquake shocks which have come to Jamaica in past years, and also has characterized many of the sequent shocks. Another man repeated his actions and found that he could jump through the fallen wall of the house and then over

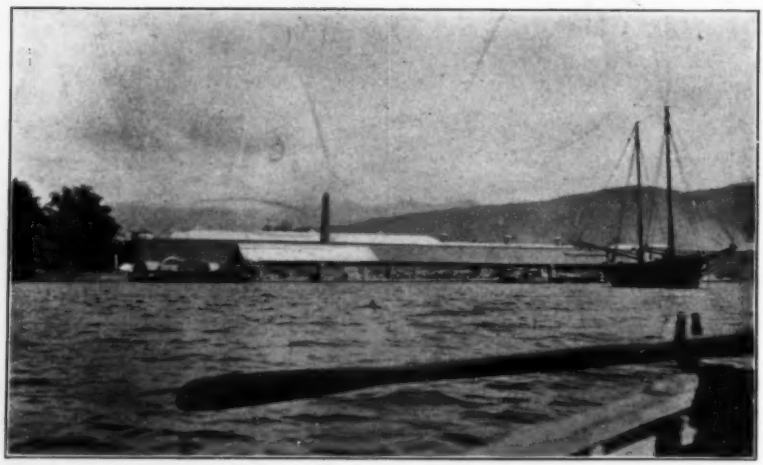

FIG. 7. LOOKING NORTH TO LANDING PLACE AT GENERAL PENITENTIARY. Massive walls cracked; a section of the eastern wall was demolished. Upper part of chimney overthrown to east.

a low fence and get into the street in about forty seconds. The increase and decrease of the tremors are so gradual that it is very difficult for an observer to tell just when the shock comes and when it ends. From the majority of the testimony it is evident that in this disaster the movement quickly reached the major climax in about ten seconds, then lessened in intensity for about ten more, then gently swelled to a second and minor climax and disappeared in a total of about thirty-five seconds.

While there were apparently no preliminary shocks at Jamaica, there have been many sequent vibrations of the earth, more or less severe. The press has chronicled one on February 23, which was the strongest since the earthquake, and another one also was noted on March 22. Mr. Maxwell Hall[6] has noticed some eighty shocks after the main shock on January 14 to February 5, several of them shaking the whole island, while others were of local extent. On the early morning of January 28 one small shock awakened me instantly by a slight shaking of my cot in the tent in which we were sheltered. The continuance of the motion gave one a sense of insecurity and unsteadiness, and brought with it a slight tinge of dread and nausea. My first impression upon waking was of a rushing, whistling sound from the southwest; it increased and passed overhead, rapidly lessening and disappearing. It was very similar in sound to the approach and passing of a large flock of ducks flying low. Then from the race-course, only a quarter mile distant and only a short time quieted, came the cries of the frightened negroes and the howls of the numerous dogs with which Kingston is cursed, and the crowing of the many roosters in the trees —as they did about every hour during the night. The shock felt on board the moving Port Antonio train produced a feeling as if the coaches were running upon the sleepers and at the same time swaying so much that it seemed as if they would topple over to the southeast. No damage, however, was done to any of the rolling stock or to the roadbed. In none of the many tunnels was any displacement observed. A man driving on the road suddenly felt his vehicle thrown in an angling position across the road and it seemed difficult for the horse to keep its footing. It was observed, however, that motion sometimes counteracted the vibration of the ground and made the latter imperceptible.

The sketch map (Fig. 1) shows by the isoseismal lines the relative intensity of the shock at Kingston as compared with other places on the island. It has seemed rather strange that the most intense destruction should happen to occur just where a large number of buildings are found. But in the case of Kingston, the gravelly foundation in proximity to the epicenter readily accounts for the destruction.

[6] Personal communication to the writer.

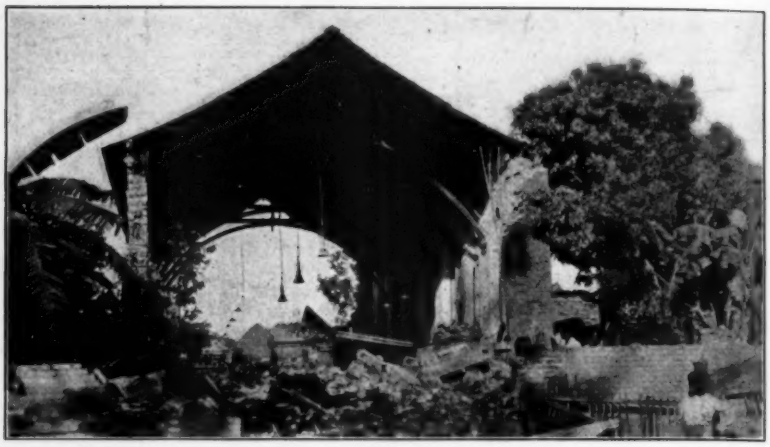

FIG. 8, *a*. EAST AND WEST GABLE ENDS DESTROYED by SHOCK.

From the data available, the dependence of earthquakes in intensity upon topography is well emphasized. Loosely compacted fringing and alluvial plains extended the intensity farther than the more compact and elastic mountain regions. Not only do these less elastic plains give a greater amplitude to the waves and cause greater destruction, but apparently the earth-waves are affected by plains indented in hills as sea-waves change their direction in entering the arm of a bay. The arrows (Fig. 1, *a*) indicate generally the direction of the wave motion. In the middle of the Hope River Valley at Mona Plantation an observer noticed the motion pass him and then saw the landslide occur at the mouth of the river to the southward. As the wave passed over the cane-fields, a motion was observed similar to that produced in a field of grain by the wind. The direction here was at right angles to the path of the wave-motion only five miles away at Kingston, situated on the western slopes of Long Mountain. The motion approached the island from the southwest, changing on the land its direction and intensity with the change in the nature of the material through which it passed. In the lower part of the city of Kingston the path of the movement was well marked by the overthrowing of walls, piers, statues, monuments, large chimneys and a similar movement toward the east of even large marble slabs covering graves (Figs. 3–9). Northward from the city the motion appeared to come more from the south, and the northern walls showed the greatest damage; and westward, the path of motion appeared to swing so that it came from Kingston. The absence of any large buildings, away from the villages and cities, made the plotting of directions rather difficult, for the lightly-built mud-wattled huts were not affected by the shock and tests by hearing are very unreliable. But there was a general diminution in intensity away from Kingston;

FIG. 8, *b*. EAST AND WEST WALLS CRUSHED.

decreasing rapidly eastward, less rapidly westward and still less so to the north. Haiti did not feel the shock, neither was it felt at Colon or at Grand Cayman, 175 miles west, but Santiago, 120 miles north, experienced a slight shock.

Cracks in buildings, which at Kingston dip some 50 degrees east, are always perpendicular to the path of the emergence of earthquake waves. Hitherto, the intensity area and epicenter have been regarded as synonymous. But the dip of the angling cracks at Kingston points to a locus of disturbance much to the west of that city, while the lines of isoseismals indicate the intensity area in the eastern half of Kingston. It may readily be imagined, then, that the area of greatest destruction may not be directly above the focus. Suppose a highly elastic rock is there situated, and some distance away is found a plain of loosely-formed material. The destruction in the latter area will far exceed that in the former in spite of its favorable location. Until we register the actual amplitude, wave-length and period and, with the elasticity of the rock underneath, calculate from the more readily-discerned data on adjacent but less elastic media the changes that have occurred in the wave-motion, it will be difficult to determine with accuracy in a region of rocks of widely varying elasticity the location of epicenters. For outliers of rock in plains must deflect, refract and reflect wave-motion and even shadow areas in these plains. The only conclusion then is that the eastern end of the Liguanea plain was the nearest area to the real epicenter that by nature of material would give the greatest amplitude to the destructive epifocal waves. Further, the angle of emergence at Kingston coordinated with the proximity of a probable epicenter, together with the limited area of disturbance, indicates a shallow origin of about three miles.

FIG 9. SHOWING THE EAST WALLS OF THE JAMAICA CLUB. Crushing of the walls by the roof and of the first story by ceilings and partitions. The majority of the first stories remained intact.

FIG. 10. STATUE OF QUEEN VICTORIA, TWISTED AN EIGHTH TURN COUNTER-CLOCKWISE FROM THE SOUTH.

The line of intensity of the earthquake destruction apparently extended to a greater distance northward than to the east or west. For at Buff and Annotta Bays on the north shore, the destruction was but little less than at Kingston. Furthermore, the shock was felt at Santiago to the north and not at Haiti to the east or on land to the west of Jamaica. The inference is that the locus of the disturbance originated in a line of north-south faulting rather than in an area of less linear extent. The north-south fault-lines extending throughout the island, as noted before, and some probable fault-lines extending in a similar direction through Cuba (marked by sharp valleys) may indicate in a general way the direction of possible faulting at the present time. It might be noted that this line of faulting lies at a considerable angle with the general trend of the Antillean folding. The

beautiful mountain road from Kingston to Newcastle was in the line of greatest intensity. But though spurs showed considerable destruction and in places the road slipped off the face of the steep slopes (Fig. 11), or portions of the hills slipped down on the road carrying it away or obliterating it by landslides in many places, yet the destruction was caused more by the unstable position of the road, or of these masses of earth, rather than by the intensity of the shock. At Newcastle, moreover, the buildings for the most part were not damaged to any great extent, except as their location on a terraced slope or on the crest of a short divide would place them in a position of unstable equilibrium. Similar destruction might be caused by a severe rain-

FIG. 11. DESTRUCTION OF THE BEAUTIFUL CARRIAGE ROAD TO NEWCASTLE, built on the steep slopes of the Blue Mountains.

storm, or, in the northern countries, by frost action as well as by earthquake waves.

From the investigation of the many cracked walls at Kingston, the amplitude of the wave motion (as one might expect on alluvial foundations) was considerable. Spaces from half an inch to two inches were left in massive walls. Floors and ceilings were pulled from the shallow supports in many cases and caused destruction in more instances than would have been necessary had there been greater foresight used in the manner of building. From an open circular well of masonry some twenty feet in diameter water was thrown up some eight feet and over the northeastern lip of this well. A brick pier in a fence was thrown to the eastward beyond its arc, some two thirds the length of its radius. At the same place large slabs of marble were moved along

FIG. 12, *a*. LOOKING EAST ALONG BELT OF FISSURING AT BASE OF THE PALISADOES, showing one of several parallel fault planes in the sand, with crateriets of mud.

FIG. 12, *b*. LOOKING SOUTHEAST ACROSS FAULTED BELT.

on their cement base to the eastward some three inches or more in spite of the attendant friction. The amplitude was probably less than an inch at Kingston.

The speed of the various waves in this earthquake can only be approximated. During a slight shock that occurred afterwards, of about one third the intensity, from an interrupted telephone conversation from Kingston to Port Antonio, it was estimated that the wave traveled about two thousand feet per second. As yet no data have been available concerning the breaking of the cables, and as to the exact time or speed as marked by such fractures. The Panama cable was broken in two places, one four miles and the other some twenty miles offshore from Bull Bay, but so covered was it with débris that a couple of miles

FIG. 15. NEARER VIEW OF SUBMERGENCE AT PORT ROYAL, looking south. Most of the area now covered by water in the photograph was formerly land.

or so of the cable had to be abandoned. The preliminary tremors were heard before being felt and probably were slower than sound-waves. With the increase of speed that comes with the augmentation of intensity of earthquakes, it is probable that the rate of the major vibrations was about ten thousand feet per second.

As has been previously stated the shock was a double one; the first climax apparently came from the west, while the second one, less disputive and more undulating in its character, apparently came more from the southward of Kingston. These two directions of vibration resulted in an almost universal gyratory movement of columns, statues, piers, sections of brick chimneys, and even of buildings, in a counter-clockwise (Fig. 10) fashion.

Geologically, earthquakes often are not very important. In the case of the earthquake at Jamaica, however, there apparently was a

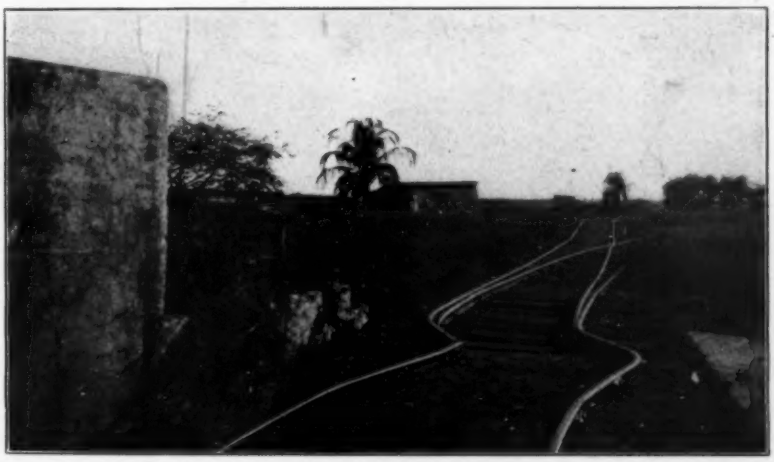

FIG. 16. TWISTING OF RAILS AND TILTING OF BUILDINGS IN VICTORIA BATTERY, PORT ROYAL, BY SUBSIDENCE.

zone of fissuring and subsidence from a hundred yards to three hundred yards in width (Fig. 1, *a*, *AA*). It started at the western part

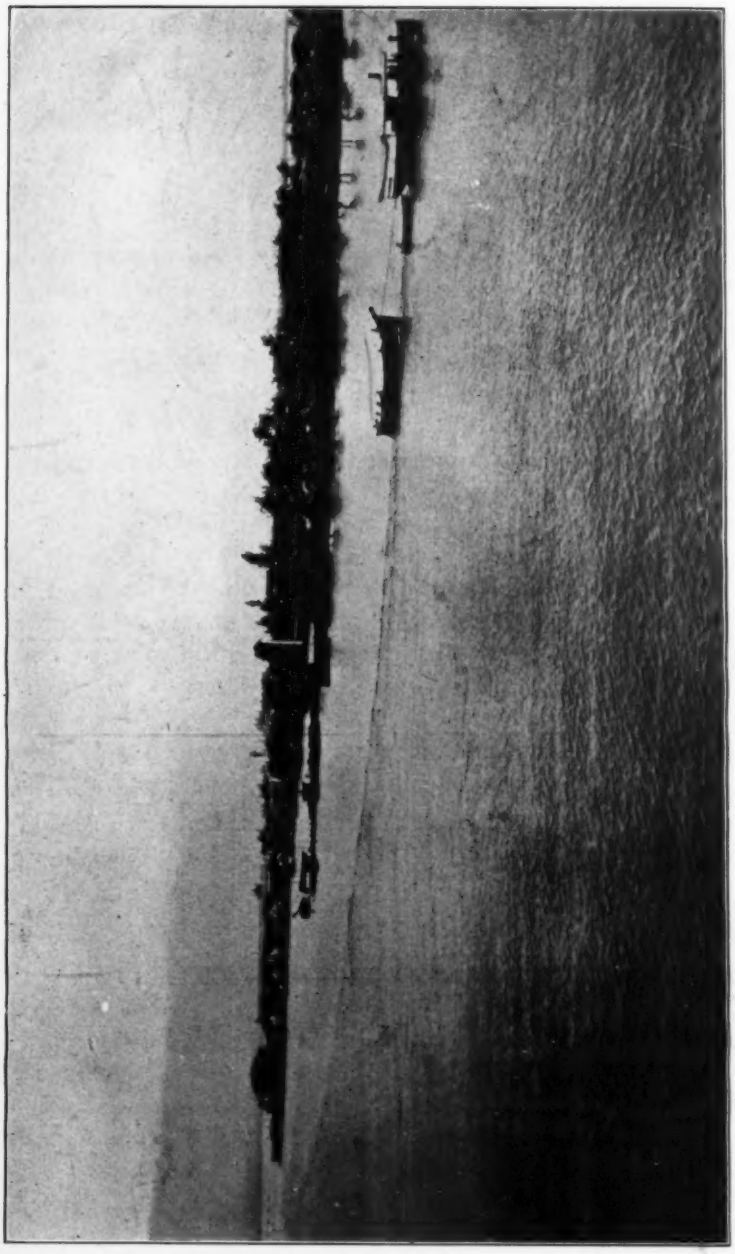

FIG. 14. LOOKING EAST TOWARD PORT ROYAL SHOWING SUBMERGED PALMS AND BATTERY CASEMATES (in line with tower). Old Port Royal formerly extended northward from the point at the left.

of the city of Kingston, ran along the water front encircling the harbor, and continued along the line of the Palisadoes, reaching its greatest destructive effect at Port Royal. One arm of this fissuring followed up

the River Cobre to the carriage road. From soundings taken by the kindness of Mr. Charlton Thompson, harbor master, it was ascertained that in several places along the edge of the harbor, the bottom had sunk from old soundings of a fathom and a half to over six fathoms, and that on the harbor side of the base of the Palisadoes a series of step-faults reached a maximum depression at the shore to the north of four fathoms (Figs. 12 and 13). This zone of disturbance continued, as far as could be traced, in an interrupted line along the Palisadoes, and caused a maximum depression at the western tip of Port Royal, where the buildings were tilted by the sinking and a hundred yards or more of land were submerged to a depth of from eight to twenty-five feet (Figs. 14–16). This fissuring of the earth was caused by the repeated tearing apart and closing of the earth's crust, accompanied generally by the ejection of water, sand and mud, sometimes to the height of three or four feet, but the subsidence prevented the forming of any cones about these craterlets. The sands first thrown up were afterwards covered by a layer of mud.

To account for the unique line of fissuring and subsidence is difficult. It was noted that considerable disturbance took place at the shore line where the earth vibrations were refracted in changing from the medium of one elasticity to a medium of a different elasticity. But the middle portions of the harbor were stable and the channel was unchanged, though a beacon light near Fort Augusta was broken off. In this limestone country, solution by underground waters might be sufficient to account for the sinking of a small area like the harbor at Kingston. But the harbor did not sink—only a small encircling zone, and that located either on the shore or slightly offshore. The continuous tearing apart and closing of these fissures, covering a few hours' time as it did in some instances, might account for the hydraulicking of the loosely compacted sands and gravels in the zone of fissuring, and allow subsidence. Again, ground-waters may have caused considerable solution of the limey constituents where the waters entered the harbor. No theory as yet satisfactorily accounts for this peculiar subsidence. At the eastern end of the harbor at Rock Fort a considerable change in underground drainage was observed, where a small spring was increased to a stream eight feet wide and six inches deep.

It was here at the Rock Fort penitentiary quarry that a guard gave me the only reliable account of a sea wave. After a few moments had elapsed and the convicts had run from the landslides on the face of the quarry and gathered around him for protection, the sea retreated for a hundred feet and then advanced inward upon the shore about sixty feet in a low wave a couple of feet high. Ocho Rios, near

FIG. 13. LOOKING TOWARDS KINGSTON, ACROSS HARBOR FROM BASE OF PALISADOES, showing width of sunken belt. Soundings of four fathoms were taken where the tree-tips emerge from the water, formerly near the old shore-line.

St. Anne's Bay, on the north shore, also had its harbor emptied for about seventy-five yards, after which a small incoming wave was followed by gradually lessening oscillations. A careful search ten days later along the other places of the harbor and coast line, however, revealed no trace of any sea wave, even of slight degree.

Thanks to the energy of the department in charge of the waterworks and to the good fortune that caused no important breaks in the system, Kingston was shut off from its water supply for only two hours. Some of its cement reservoirs situated near a large wrecked school building showed no damage. The pipe that carries the city's sewage eastward to the sea at the base of the Palisadoes, however, was broken at several places along the zone of fissuring, and its linear extent, like that of the water pipe along the Palisadoes, was marked by rifting in

the earth. A prompt repairing of the breaks in these two systems undoubtedly saved the city from an outbreak of destructive pestilence.

Arches in buildings apparently withstood the shock to a notable degree, whether transverse or parallel to the line of the earthquake motion. Generally when built in houses they preserved the parts around them. The Institute, a building in which some two hundred delegates had assembled in the first session of the West Indian Agricultural Conference, is built on two lines of arches at right angles to each other. The Institute was damaged, but withstood the shock. The great destruction of brick buildings in Kingston was doubtless due to the fact that poor mortar and dry bricks were used in the construction. The mortar generally appeared to be rather porous and usually the cracks in the wall followed the mortar, though at Up Park Camp, where the bricks were laid in cement mortar, the cracks passed through the bricks.

The streets were narrow (Figs. 4 and 5), so that the falling wall of even a two-story building would block the street, and many persons escaped from falling buildings only to be crushed in the choked narrow streets. A cement floor may help preserve a building from destruction. In many cases it could be seen that if the floors had been well tied to the walls and the walls themselves held at the corners, a great lessening of the destruction would have resulted. On account of the white ants foreign woods are, unless creosoted, difficult to use, but some frame houses showed but the slightest effect of the earthquake shock. The 'barrack' or 'noggin' structure, much used in earthquake countries, apparently suffered nearly as much as other brick walls.

Jamaica lies in a region of great differential relief and consequent stress. The earthquake was confined in its area of greatest destruction to small limits upon alluvial detrital material, where the amplitude was increased to bring about this effect, varying with the heterogeneity of material. The origin of the shock was comparatively shallow and the earthquake was local in character. While there was a general distinct rotary motion induced by two components of the vibrations, the major component came from a westerly direction. There were few evidences of sea waves, but there was a unique zone of fissuring and subsidence about the harbor of Kingston. Finally, the disasters at San Francisco, Valparaiso and Kingston should teach the lesson that in the case of cities located in a danger zone (where there are many recurring shocks of slight degree), there is always a possibility of the coming of a disastrous shock; that certain types of buildings should be built and streets laid out with that possibility in mind; that water, sewage and lighting systems should be planned in sections, and that as far as possible a city should not be located nor large edifices erected upon uncompacted rocks and soils.

NOTES ON THE DEVELOPMENT OF TELEPHONE SERVICE

By FRED DE LAND
Pittsburg, Pa.

IN November, 1876, Graham Bell perceived the value and efficiency of the metallic circuit and advised its adoption for telephone service to overcome the inductive annoyances. On February 1, 1878, the parent Bell company recommended the use of metallic circuits for

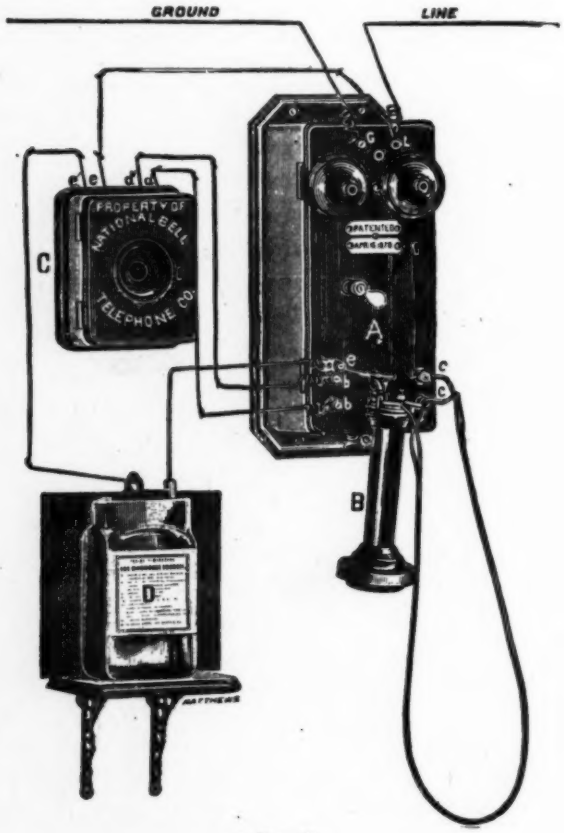

Fig. 30.

exchange service, although only three telephone companies had exchanges in operation that month. But many of the local companies could only perceive that the introduction of a metallic-circuit system meant double the cross-arm space, stronger poles, double the terminal

equipment, the rapid displacement of open wires with cable, etc. Then, in August, 1877, Graham Bell showed the advantage of twisting 'the direct and return wires around one another, so they should be absolutely equidistant from the disturbing wires' in order to neutralize the effect of the inductive current and eliminate the noise.

Many experiments were made to invent an improved transmitter that would overcome the inductive effect and yet retain the marvelous simplicity of the hand telephone, with its entailed low cost of maintenance. But eventually it was perceived that the displacement of the magnets in the simple self-contained telephone was possible only

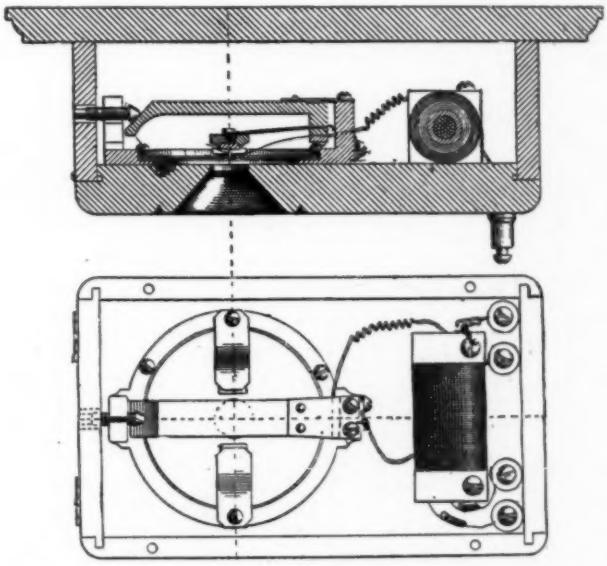

FIG. 31.

through the introduction of a battery current and the employment of much mechanism that has always carried relatively heavy maintenance charges.

In the winter of 1878–9, the more progressive companies began to install the Blake transmitter in combination with the rubber-encased Bell receiver and the magneto bell. At the close of 1878, 246 Blake transmitters were in service, and by July 1, 1879, the number had increased to 7,000. On noisy circuits this change afforded a marked improvement in service that was highly appreciated by local subscribers. Several modifications in the form of these telephone sets (Fig. 30) were sent out before a standard type was selected. Even then, as there were several factories licensed to manufacture under Bell patents, the output of each, while not essentially different, bore distinctive trade-marks. In each the battery wires were led into the

bell box so that the battery circuit might be under the control of and closed and opened by the telephone hook switch. Interior and sectional views of the Blake transmitter are shown in Fig. 31. With each of these early Blake instruments a circular was sent stating that it

can be used only as a transmitter, and requires a telephone to hear with. This is the most complete and perfect set of instruments that can be used for telephonic communication. It will transmit the faintest whisper with perfect distinctness.

It is a fact that no modern transmitter exceeds the Blake in clearly and distinctly reproducing the articulation of the subscriber. But owing to the mechanism employed in its single contact form, it proved deficient in volume or power required on noisy and on long suburban lines. Again, its first cost was comparatively low, and the Blake and similar types of transmitters possess the striking advantage over the old hand telephone of being placed on a local circuit, thus removing their varying resistances from the line circuit, to the improvement of the qualities of transmission. The old hand telephone and the early box magneto telephone formed a part of the main-line circuit, thus materially increasing its resistance.

The first Blake instruments were larger in whole and in part than the transmitter so familiar to all telephone users, while the screw that controlled the proper adjustment of the electrodes projected through the box, thus making it possible for the subscriber to adjust the instrument for long circuits or short lines, regardless of the mood he might be in. It only required a little experience to teach the local companies that the wiser plan was to have trained telephone inspectors do the necessary adjusting. So the adjusting screw was put inside the box and the door fastened with lock and key.

There is a wide difference between the underlying principles of Bell's self-contained transmitter and his variable resistance transmitter, both of which were exhibited at the Centennial. The microphone, or carbon, or battery transmitter, now in use on nearly all telephone lines, belongs to the variable resistance type. Unlike the early hand transmitter, it does not generate current, but serves as a voice-governed mechanical regulator of the flow of current chemically generated in a battery.

After Graham Bell had shown how to solve the problem of speech transmission, many other inventors were naturally quick to suggest commercial improvements. A few worked hand-in-hand with Graham Bell and gladly contributed to his success. Among this number was Francis Blake, Jr., who invented the transmitter bearing his name and which was the only transmitter used on a majority of the Bell lines prior to 1893. Mr. Blake was a Christmas present in 1850; graduated from the Brookline, Mass., High School in 1866; entered

the United States Coast Survey, and during the next three years assisted in the transcontinental longitudinal determinations. Finding it necessary to make many experiments in determining the velocity of telegraphic time signals over long circuits, he made a thorough study of electricity. In 1869 and again in 1872 he was in Europe and made all the observations in the third and final determination of the difference of longitude between Greenwich, Paris and Cambridge. Subsequent observations by European astronomers confirmed his work. During 1874–6, he was preparing the results of his transatlantic work for publication, and during this period became acquainted with Graham Bell. On April 5, 1878, he tendered his resignation, which was accepted with the greatest reluctance to date April 15. During the four years that had elapsed since his return from Europe he had devoted all his leisure to experimental physics. It is recorded that in carrying on these experiments

he had become an enthusiastic amateur mechanic; so that at the time of his resignation he found himself in possession of a well-equipped mechanical laboratory, and a self-acquired ability to perform a variety of mechanical operations. Under these conditions what had been a pastime naturally became a serious pursuit in life; and within barely a month of his resignation, April 5, 1878, Mr. Blake had begun a series of experiments which brought forth the Blake transmitter.

Other workers were also successful in serviceably utilizing the 'loose contact' or microphonic principle in the telephonic transmitter. In January, 1877, Emile Berliner devised his well-known transmitter, for which he filed a caveat on April 14. It was referred to in the Washington *Critic*, May 18, and on June 4, 1877, he filed an application based on his caveat. The patent was issued January 15, 1878. On April 27, 1877, Thomas A. Edison filed his application for a patent on a battery transmitter; while in December, 1877, Professor Hughes commenced his now famous microphonic experiments, which were followed by Hunnings's employment of carbon granules. One of the first of the Berliner transmitters is illustrated in Fig. 32

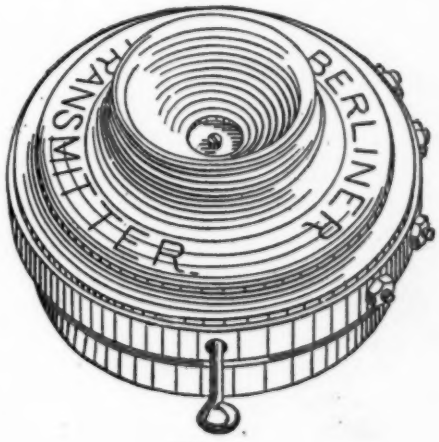

FIG. 32.

Referring to some of these experiments with carbon electrodes, Sir William Thomson (now Lord Kelvin) wrote:

It does seem to me that the physical principle used by Edison in his carbon telephone, and by Hughes in the microphone, is the same, and that it is the same as that used by M. Clerac in the variable resistance carbon tubes which he had given to Mr. Hughes and others for important practical applications as early as 1866, and that it depends entirely on the fact, long ago pointed out by du Moncel, that increase of pressure between two conductors in contact produces diminution of electric resistance between them.

Bell's hand transmitter was not only a telephone complete in itself, but was a self-contained generator of the alternating-current type. It was operated by the voice creating sound waves that in turn generated electric waves through the movements of the diaphragm. These electrical waves were similar in form to the sound waves and were transmitted to the receiver and there changed back to sound waves. When in operation the flow of the current, and every variation in its strength, was dependent on the varying motions of a diaphragm moving in a magnetic field; that is, on the speed of an armature of a miniature dynamo driven by the spoken word. In other words, in the hand telephone respondent vibratory motion of a soft iron induction armature in a magnetic field was the essential element in the successful transmission of speech.

In the Blake and other forms of variable resistance transmitters, whether single or multi-contact, there is no electro-magnet and no armature. A battery, usually of the sal-ammoniac type, supplies a constant current, the flow of which is regulated by increasing or decreasing the pressure of the diaphragm against the carbon button, the changes in pressure being governed by the impact of the changing sound waves on the diaphragm. Thus a carbon transmitter is not so sensitive, nor does it possess that delicate responsiveness so noticeable in a magneto transmitter. It matters little what may be the nature or character of the diaphragm in a variable resistance transmitter, so long as it is sensitive enough to reciprocally respond to the sound waves produced by the vocal cords. But only a soft iron inductive diaphragm will serve in the magneto type of transmitter.

In the White or solid-back transmitter, now so familiar a part of Bell equipment, the single-contact feature of the Blake transmitter is succeeded by a multi-contact arrangement composed of two carbon electrodes made of the hardest of pure carbon separated by carbon granules. The selected granules insure a multitude of contacts, and talking qualities that are unexcelled.

In all these variable-contact transmitters the current is always knocking at the carbon gateway and seeping through. When the telephone is not in use, the carbon offers just sufficient resistance to prevent the current from forcing the gate wide open. When a person is talking, the vibrations of the diaphragm decrease the resistance of the carbon and enable the current to flow through the partially or wholly opened gateway.

Unlike the hand telephone in every respect, the Blake transmitter consisted of a small black-walnut box, nearly square in form and having a funnel-shaped hole cut in the door to serve as a mouthpiece. Within the box was a soft iron diaphragm and suspended parallel to its center was a polished button of pure carbon; between the two hung a German-silver spring bearing a pellet of platinum which barely touched the center of the carbon. When the Blake transmitter was in use, the impinging sound waves pressed the diaphragm against the platinum and forced it with varying pressure against the carbon button. This changing pressure varied the resistance offered to the flow of the battery current, which pulsated through the carbon and into the primary winding of an induction coil or transformer, where it was converted into an alternating current through the inductive effects of the secondary winding and passed out in undulating or wave-like form into the line or subscriber circuit, thence through the copper wire in the green-covered telephone cord attached to the receiver, and on into the wire wound on the electro-magnets. Energizing the latter varied the attractive or pulling power of the pole pieces, thus causing the receiver diaphragm to vibrate in a manner exactly reproducing the vibratory motion of the transmitting diaphragm and setting up a series of sound waves in the receiver exactly corresponding to those produced by the vocal cords of the speaker.

So sensitive is a properly adjusted telephone diaphragm that its vibrations may cause several hundred thousand variations a minute in pressure of platinum point on carbon button in the Blake transmitter, or between carbon granules in certain other microphonic forms Naturally the amount of current thus passing through this carbon gateway is extremely small, depending principally on the pitch of the speaker's tone and the physical condition of the line. Under ordinary circumstances and with both telephones and a complete copper circuit in good condition, distinct transmission of speech only requires a maximum generation of about one tenth of a milliampere of current at any one period, or only a millionth part of the current required to light an incandescent lamp. Again, probably only one fourth or less of even this infinitely small amount of current reaches the electro-magnets in the receiver, the other portion being used up in overcoming resistances. Where the circuit is three or four hundred miles in length, it is probable 'that only about one one-hundredth of the original current produced at the transmitting station is finally utilized at the receiving station.'

Where operating companies desired a less expensive instrument than the standard Blake set, for use of small users of service, only willing to pay a low rate, a much cheaper set (Fig. 33) was supplied. This set was originally intended to be used only on private lines, or

for educational purposes; that is, to gradually acquaint the subscriber with the convenience and value of having a telephone in the home. A glance at Fig. 33 shows that *A* is an electric tap-bell, *B* the hand telephone or receiver, as it is now called, *C* the Blake transmitter, *D* 'an automatic switch on which the telephone must be hung when not in use,' and *E* the signalling key.

Installing the regular Blake telephone sets in residences was not an easy task by reason of there being three separate parts to find location for, the magneto bell and receiver, the Blake transmitter, and the batteries (Fig. 30). So much opposition was encountered in handsome homes where the owners objected to the disfigurement of walls,

FIG. 33.

FIG. 34.

that immediate efforts were made to devise more compact forms. Finally the different parts were all merged into the oblong set or wall telephone (Fig. 34) so familiar to users of telephone service. An elaborate Gilliland set, designed for use in the better class of residences, is shown in Fig. 35. The battery was kept in one drawer, and pencil, memorandum book, etc., in the other. The Law set used in New York City in 1879–80 is shown in Fig. 36.

Some years ago it was asserted that all the credit for this serviceable arrangement belonged to a grocer in Denver, who, all unconscious of the value of the idea to telephone companies, fastened the magneto

bell to a partition in his store, attached the Blake transmitter below the magneto, and screwed an empty soap-box underneath the transmitter. He placed the batteries in the box and made the top of the box serve as a desk on which to record orders received over the telephone. It is said that the partition suggested to an observant telephone man the back-board of the present telephone set, while the soap box suggested the usual battery-box. At any rate, about that time began the movement towards uniformity in equipment, economy in maintenance and artistic serviceability in installation. No matter how expert the installer, it was a difficult task to quickly and neatly install several parts of a telephone set, where each part had to be firmly attached to the wall, especially in handsome residences. Thus the more compact forms were welcomed innovations. But they had one

FIG. 35.

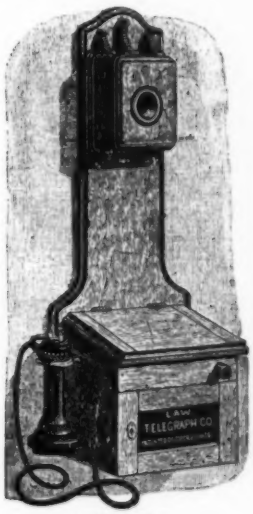

FIG. 36.

exasperating defect. The Blake transmitter, instead of being placed flush with the front of the bell box was set in so far as to lead to much vexation of spirit, through the subscriber's forehead coming in contact with the bell box.

In referring to the early telephone equipment, Mr. B. E. Sunny stated, in 1887, that

the field for improvement in the construction of subscribers' apparatus is a particularly broad one. The entire outfit is crude and defective, and it represents a smaller growth towards perfection than anything else that we have in the service. The magneto as constructed to-day (1887) is a cheap looking affair, except the new Gilliland, and they are all more or less unreliable, while after ten years' experience we ought to have an instrument that would look in keeping with the furnishings of the finest residence or office, and that would be free from electrical defects.

The parent Bell company perceived the wisdom of standardizing its equipment long before it decided on uniformity in line construction. With that end in view, as well as 'to obtain a permanent interest in the manufacture of telephones and switchboards,' in 1881, it purchased the factory and business of Charles Williams, Jr., of Boston, where Graham Bell had carried on his early experiments, and where the first several thousand telephones were made. It also bought an interest in the Western Electric Manufacturing Company of Chicago and merged the two into one organization, which, under the later name of Western Electric Company, has grown to be the largest industrial plant of its kind in the world, occupying more than seventy acres of floor space, employing more than twenty-five thousand persons, and with sales exceeding $70,000,000 annually.

In connection with the early selection of a permanent manufacturer, Mr. T. B. Doolittle, formerly an experienced manufacturer of metal goods, makes the following statement that indicates how easily the city of Bridgeport, Connecticut, might possibly have had a manufacturing establishment similar to the Western Electric Company:

My interest in mechanics and manufacture led me to spend much time in the factory of Mr. Charles Williams, Jr., in 1877–78, and to offer suggestions regarding the details of construction. For example, I substituted the bell 'struck up' from sheet metal in place ot the cast and turned bell, thus reducing the cost from about fifty cents to about five cents. I also brought about a large reduction in the cost of the cabinet work used in the manufacture of switchboards and telephone apparatus. These large savings attracted the attention of the management of the parent company, and I was authorized to find a manufacturer having a factory properly equipped and enter into negotiations for the manufacture of telephone equipment. I visited several factories in Connecticut, among others the Wheeler & Wilson Sewing Machine Company, at Bridgeport, but found none who were willing to enter into such a hazardous undertaking and one that promised so little future growth. I endeavored to convince Mr. Wheeler that the future was rich in promise, and that his company would not only become a licensed manufacturer, but, in all probability the permanent manufacturer. But though trade was slack, he would not entertain my proposition.

SIGHT AND SEEING IN ANCIENT TIMES

By Dr. CHARLES WILLIAM SUPER
ATHENS, O.

WHEN we pass along the streets of our cities and large towns and observe the number of persons between the ages of twenty and forty who wear spectacles; or again, if we inspect the eyesight of the children of our public schools and of the young people in our colleges, we find that a large proportion of the present generation is afflicted with visual organs more or less defective. More than this, there is hardly a person over fifty who does not use some sort of artificial aid to sight. In the German universities the situation is still worse. There, apparently, almost one half of the students wear eye-glasses. England furnishes a marked contrast; spectacles on the eyes of young men and young women are far less common. The chief reason doubtless is the fondness of both sexes for outdoor life. It is highly probable that our somewhat abnormal eyesight is chiefly due to the abnormal conditions under which we live. The epithet *abnormal* is of course to be understood in a relative sense; it is not strictly applicable to a highly developed stage of civilization. It can not properly be said that the conditions under which the Papuans or the Bushmen live are more natural than those of the residents of London or New York. Each generation is, in a sense, weaker but also wiser; what is lost in one direction is more than made up in another. Still, the injudicious use of the eyes in artificial light and a short range of vision seem to be inevitably imposed upon the dwellers in cities. It is a well-established fact in hygiene that any bodily organ is strengthened by the wise use of it. This being the case, it follows that persons who spend much of their time out-of-doors and in looking at objects afar off, or who use their eyes but little after nightfall, will retain their sight unimpaired much longer than do most people of the present day. On the other hand, failing vision is the natural concomitant of advancing age, so that the number of persons beyond sixty who see clearly with the naked eye is exceedingly small and probably was never very large.

Moreover, the human eye is said to be a rather ill-contrived piece of mechanism. A celebrated German physicist is reported to have remarked that if an artisan were to make for him a piece of apparatus so poorly adapted to its purpose he would not accept it. Biographers have, however, preserved the names of a considerable number of persons from the remote and more recent past whose mental faculties were unimpaired at fourscore and beyond, though it is not often that this could be affirmed of their sight. The last chapter of Deuteronomy

informs us that Moses was 'an hundred and twenty years old; his eye was not dim nor his natural force abated.' There is nothing incredible in this record, for similar instances are not very rare. A colored woman died in Philadelphia in January, 1906, who seemed to have pretty clear recollections of Washington at Valley Forge. Her friends claimed for her the age of one hundred and thirty-five. A writer in a recent issue of the *Monthly Review* mentions a number of Kaffirs still living in 1885 who professed to have taken part in a battle in 1818. Burton made the acquaintance of a chief, whom he described in 1857 as a very old man; but eighteen years later Cameron found him still ruling his people and very little changed in appearance. While Humboldt was in Lima an Indian died there at the age of one hundred and forty-three. "Blindness overtook him at the age of one hundred and thirty, but till that misfortune he used to walk three or four leagues daily." He also declares that during his five years' residence in Mexico and South America he saw no person afflicted with bodily disease or even with squinting. Tschudi says that one hundred and thirty years 'with unimpaired faculties' is not at all uncommon in Peru. These references are doubtless to natives; and what is true of the so-called lower races does not necessarily hold good of the more advanced peoples. Among the more recent cases that are thoroughly authenticated are the Hon. David Work, of Fredericton, N. B., who died in 1905, nearly one hundred and two years old. He was a man of mark in his community, and mentally and physically sound almost to the end. The celebrated French chemist, Chevreul, who died in Paris in 1889, was about a year older. John Wesley at eighty-five writes that he is "not quite so agile as he was in times past and his sight is a little decayed." Most persons, unless their observations have been very limited, have met individuals who lived close upon fivescore years or even beyond. Several Roman writers likewise give 120 years as the utmost limit of human life. Sight is preeminently the civilizing sense; upon it all progress depends, or, as Oken expresses it, "Sight is the light sense. Through it we become acquainted with universal relations, this being *reason*. Without the eye there would be no reason." The same thought is expressed in the Sermon on the Mount: "The lamp of the body is the eye. If your eye is unclouded your whole body will be lighted up; but if your eye be diseased your whole body will be dark." Not only painting, sculpture and architecture are dependent upon sight, but language also as soon as it becomes the transmitter of experience, whether inner or outer, from age to age. Those peoples that never cultivate speech beyond the point where it is perceived by the ear alone, never advance farther than the primitive stage. But as soon as speech becomes cognizable by the sight, it can be employed to fix the experience and the accumulated knowledge of each generation. It is by means of our eyesight that we are able to learn the

thoughts and, to some extent, the feelings of the people of the most distant ages and the most remote regions, almost as well as those of our intimate friends. Yet when we remember that man has left intelligible traces upon the earth, dating back at least seven thousand years, and compare their testimony with the world, say three hundred years ago, we are not conscious of a great advance either intellectually or socially. It is evident, therefore, that important as sight is to man, something more is needed to make him progressive. As soon as the mind becomes fossilized by tradition all advance ceases. If, on the other hand, we compare the world about A.D. 1600 with its condition at the present day, we are constrained to marvel at the advance that has been made. In fact it is not putting the case too strong to say that if by progress we mean man's power over matter, it has been greater during the last fifty years than during all the preceding time of his abode upon the earth. No more striking example of the stationary condition of mankind in certain relations exists than that furnished by artificial lighting. The situation in 1800 was virtually the same that had existed from the earliest times. Torches were used out-of-doors and lamps indoors. Many of the latter found in Grecian and Roman tombs served their purpose just as well as some of those used within the memory of men now living. Friction matches did not become general until about the middle of the last century. It is sometimes said in a tone of deprecation that as the realm of science increases that of poetry diminishes. Yet the fact is that the appreciation of the beauties of natural scenery has advanced with the careful study of nature. There may not be a realized connection, for poets are rarely scientists; albeit both have often been equally close observers, even if not found in each other's company or united in the same person. Few men have written more appreciatively or more sympathetically of the beauty and grandeur of natural scenery than geologists not a few; and geology is among the most modern of the sciences. The botanist who sees vegetation not only with his corporeal eye, but with his mind as well, derives a keener enjoyment from the beauties of vegetable life than does he who can not see beneath the surface; who has no conception of the forces that make plant life what it is.

To the ancients, especially to the Greeks, sea and stream, forest and field, mountain and moorland, were peopled with animate beings, it is true, and their imaginations seem to have sported in a region that is virtually closed to us moderns. On the other hand, while these beings were objects of interest they were also sources of terror; they were quite as often the doers of mischief as the bringers of blessings. Storms and lightning, floods and volcanic eruptions, are still natural phenomena to be feared, but they are no longer looked upon with superstitious dread as something to which man must submit with a blind and unreasoning fatalism. Their devastations can in some measure

be guarded against and mitigated. Such lines as the following from Bryant could not have been written by a Greek poet since they express sentiments to which entire antiquity was a stranger:

> Look on this beautiful world and read the truth
> On her fair page; see, every season brings
> New change to her, of everlasting youth;
> Still the green soil with living joyous things
> Swarms; the wide air is full of joyous wings,
> And myriads still are happy in the sleep
> Of ocean's azure gulfs, and where he flings
> The restless surge, eternal love doth keep,
> In his complacent arms, the earth, the air, the deep.

The same affirmation may be made of Bryant's 'To a Cloud,' 'To a Waterfowl,' and other of his poems not a few; or of Shelley's 'Cloud' or the 'Skylark,' and many more. In Plato's Phædrus, one of the characters says: "Here is this lofty and spreading plane-tree, and the agnus castus high and clustering, and the fullest blossom and the greatest fragrance; and the stream which flows beneath the plane-tree is deliciously cool to the feet. . . . How delightful is the breeze; and there is a sound in the air shrill and summer-like which makes answer to the cicadæ." Here we have, it is true, a flash of the love of nature. But some centuries later Plutarch refers to this passage as rather silly. While we are not sure that he is uttering his own sentiments, such seems to be the case.

In reading Greek authors we are perpetually confronted by the fact that they were acute thinkers and poor observers. They used their minds a great deal more than their senses. When they undertake to explain phenomena, they usually try to think out an explanation instead of first taking care that the phenomena in question have been correctly observed and registered. As for the Romans, not one of them ever had an original idea except on matters that could be turned to practical use.

Tacitus, for example, says that north of the Orkneys the waters are so sluggish, according to report, that they yield with difficulty to the oar and are not even raised by the wind. He then proceeds to assign as a probable reason that the extreme depth of the water makes it difficult to set in motion. Equally lucid is his explanation of the long days in the same region. Believing that night is produced by shadow, he tells us that owing to the flatness of the earth the darkness does not rise sufficiently high to reach the sky and the stars. He did not know that the nights are equally long. The Greek original from which our word eclipse is derived means a 'leaving' or 'departure.' So Herodotus, when speaking of an eclipse, says, the sun "Suddenly quitted his seat in the heavens and disappeared, though there were no clouds in sight, but the sky was clear and serene." This is quite equal to an argument I once heard upon the question whether the moon is inhabited. The rustic logician declared that such could not be the case

because the people would have no place to go when it began to decrease. What an immense amount of speculation and calculation the Ptolemaic system made for the astronomers! The philosophers all agreed with Pliny that 'with the mind we see, with the mind we discriminate'; but unfortunately they too often forgot that the mind can not discriminate unless the senses have correctly furnished the facts. So far as sight is concerned, this is strikingly exemplified in all the work of the well-known mathematician, Euclid. As he knew nothing about refraction and had no rational theory of light, he had recourse to philosophy to provide him with a basis for his work on optics, but which is really a treatise on perspective. So far as is now known, the first man who made a study of refraction was Posidonius, who lived nearly two centuries after the father of geometry. He illustrated the principle by the familiar experiment of placing a coin on the bottom of an empty vessel in such a way that it was not visible because of the intervening rim, then bringing it into sight by filling the vessel with water.

The ancients were almost entirely without apparatus and had no instruments of precision; in fact, very few of them had any interest in the mechanic arts. Though Thales foretold an eclipse of the sun as early as B.C. 600, neither the Greeks nor the Romans had any way of measuring time that was even approximately accurate. Under the republic the normal Roman year contained only three hundred and fifty-five days. Julius Cæsar very nearly corrected the error, although in the time of Pope Gregory XIII., the year had become eleven days too long. It has ceased to be a matter of controversy whether the christian era is four years too short. There is hardly any doubt that the authors of the Homeric Poems had a very undeveloped color-sense. It is highly probable that two or three millenniums ago the countries about the Midland Sea, especially the Ægean, displayed to the appreciative beholder many glorious landscapes which the destruction of the forests and the drying up of the perennial streams have completely obliterated. Not a few streams that formerly flowed all the year round have become temporary torrents, more baneful than beneficent in their effects or beautiful to behold. Many hills that were once covered with natural vegetation now present a parched and barren appearance. In the Homeric Poems we find epithets not a few that felicitously describe natural objects, or at least characterize them, but they are the result of a happy instinct rather than a careful observation. In the long 'Hymn to Demeter,' not many lines are given to an enumeration of the flowers that spring so profusely from the bosom of the earth. The treatment of the subject is perfunctory and superficial. In the much shorter 'Hymn to the Earth, the Mother of All,' flowers are barely mentioned and not particularized. In the brilliant descrip-

tion of the gardens of Alkinous, the author of the 'Odyssey' tells us there "grow tall trees blooming, pear-trees, and pomegranates, and apple-trees with bright fruit, and sweet figs, and olives and their blossoms. Some of the fruit is always ripening, yet there is a constant bloom on the trees and much unripe fruit. There too, skirting the farthest line, are all manner of garden-beds, that are perpetually fresh." We have here a sort of combination of orchard and vegetable garden, for plainly the writer had in mind utility rather than beauty. At any rate there is nothing in this quotation, in which the author had literally sent his imagination on its loftiest flights, to indicate that he knew cultivated flowers. The same may be said of 'Calypso's Isle.' The Greeks considered crowns of flowers or leaves of some kind indispensable at every banquet and revel. Anacreon, the prince of voluptuaries, frequently refers to this well-known custom. The material of which the wreath was made does not seem to have been regarded as of primary importance. The symbol only, not the substance, was essential. According to Xenophon, when some of the ten thousand in Armenia in the depth of winter were invited to a feast by one of the native chiefs, the revelers crowned themselves with hay. The will did duty for the deed. This story reminds one of the Arabs, who are punctilious in performing the stated ablutions enjoined by the Koran. But as water is sometimes too precious to be wasted in this way, they use sand, which, mixed with a liberal amount of credulity, is to the faithful equally efficacious. The extracts from Homer recall the so-called hanging gardens of Babylon constructed for Semiramis more than two thousand years before Christ. These constituted a park built on an artificial elevation, so that the epithet usually applied to them would be equally suitable to the grounds at Versailles or the Buttes Chaumont in Paris—all hung on the ground. The Persian monarchs and noblemen maintained extensive pleasure-grounds, in which great quantities of game were enclosed. It is from their designation of these parks that we get our word Paradise. It comes to us from the Greek, and is found in nearly all the modern European languages. The general opinion, however, is that the first parks, in the modern sense of the term, were the work of the Roman emperors.

Homer has no word for 'color' nor for any of the primary colors. In like manner the term usually translated 'black' is very indefinite. It is used of the bronzed complexion of Ulysses and of his henchman, Eurybates; of the ripe grape; of beans; of wine, and of the storm cloud. We moderns would say that it is strictly applicable in the last case only; certainly the difference between the hue of the storm cloud and the darkest complexion of a white man is very marked. Of Agamemnon it is said that he 'stood weeping like unto a fountain of dark water that from a beetling cliff poureth down its black stream.' In the 'Odyssey' it is said of Ulysses that 'Athena shed great beauty

from his head downwards . . . and from his head caused deep curling locks to flow like the hyacinth flower.' This comparison, which is made twice, is absolutely incomprehensible to us, if it has reference to color. It is also noteworthy that the epithet which is variously translated 'golden,' 'fair,' 'blond' is so applied to most of the Greek heroes and to horses. Evidently the author of the Homeric poems believed that the Greek nobles did not have the usual dark complexion of the southern races. Be that as it may, we can not resist the conviction that in primitive times the various shades of color that made the same general impression on the sight were named alike. There was hardly any discrimination of the sensations. Homer's usual method of designation of colors is by comparison; hence such words as 'steel-blue,' 'saffron-colored,' 'blood-red,' 'vermilion-cheeked' are common. A table has 'dark-blue' feet; the same adjective is also applied to the prow of a ship, to hair, to a horse's mane and to the eye. Fear is said to be *chloros* (of a greenish yellow). Still, this is hardly more curious or more inexact than Shakspere's 'green-eyed monster,' and the current phrase 'to turn green with envy.' It is not easy to discover the underlying idea. The same epithet is translated 'blood-red' when applied to a serpent and 'tawny' when used of the color of jackals. Though the Homeric Greeks were in some respects a good deal more advanced than our Indians, in the appreciation of the beauties of nature, they were not very wide apart. Henry T. Finck, in his 'Primitive Love,' adduces plenty of evidence to prove that the "Indians have no conception of the romantic side of nature—of scenery for its own sake. To them a tree is simply a grouse-perch, or a source of firewood; a lake, a fish-pond; a mountain, the dreaded abode of evil spirits." He assures us that the real Indian and the Hiawatha Indian are just as much alike as fact and fancy. In Homer's circle there was no interest in flowers or blossoms and no mention is made of garlands, although they played so important a part in the social life of the later Greeks. When flowers are mentioned at all it is almost solely on account of their color, which serves as a basis of comparison. One exception that I recall is the passage where one of Priam's sons is smitten with an arrow so that: "Even as a garden poppy droopeth its head aside, being heavy with fruit and the showers of spring; so bowed he his head aside laden with his helm." The Homeric Poems are supremely important for the insight they afford into the early civilization of the people which they portray, but they contain a great deal that is repulsive to our far more refined sensibilities. Empedocles speaks of but four colors: white, black, red and pale green. It is hard to believe that the age in which this philosopher lived knew at most only two prismatic colors. It is more probable that he regarded green and blue, and perhaps some other colors, as derivatives from these and therefore not entitled to separate enumeration. According to Democ-

ritus, there are but four primitive colors, from which all others are formed by combination. He seems to have regarded blue and green as variants of black. Aristotle thought there were only two primitive colors: light or white and black or dark, and that all others were produced by a mixture of these. Wide as this is from the mark, it shows a tendency to simplify natural phenomena, though it would doubtless be going too far to suspect in this belief an inkling of the composition of light. In the Old Testament four prismatic colors are mentioned, three of them very often and yellow four times, three times in Leviticus and once in the Psalms. In the former, it is used of hair; in the latter, of gold. As the Hebrews were surrounded by nations that had made great advances in technical skill, it is probable likewise that all of them had made greater advances in the discrimination of colors than the Greeks.

The fact that the ancients habitually speak of only four colors is almost proof positive that they did not discriminate more. In addition to the evidence already cited, there is to be added that of painting. What is known of the art of Polygnotus, the earliest of the distinguished painters of antiquity and a contemporary of Pericles, leads to the conclusion that he used no greater number, according to the ideas of his time. Like all early painters he worked on terra-cotta vases and on walls, not on canvas. It seems highly probable that throughout antiquity no distinction was made between orange and yellow, nor between indigo and blue, nor between the darker colors that shade into black. Many of the lower races, both at home and abroad, share this defect. Both have also the same liking for what is gaudy and striking. It is probable that the fondness for 'loud' colors is a species of survival that may be studied in children and in persons that are color-blind. The latter defect is a species of arrested development, and being an organic defect can not be overcome. On the other hand, some primitive races are reported to exhibit a very acute color-sense. This mental condition has likewise its analogy among children, some of whom are indifferent to colors, while in others the color-sense shows itself very early. At any rate, modern analogies will not enable us to decide the question for or against any people of antiquity. Two theories have long been held to account for the poverty of terms to designate colors in remote times. The one most in harmony with the evolution hypothesis is that the color-sense has followed the general law of development; the other, that primitive races perceive colors as clearly as we do, but that their languages lack words to designate minor differences. Color-blindness has no connection with mental power in general. It is well known that the celebrated physicist, John Dalton, was not capable of distinguishing more than three colors. Many similar cases are on record. This defect has become known as daltonism or achromatopsia. A more correctly constructed compound would be

chromatuphlosis. However, technical terms often lead the philologist to express the same opinion of them that the devil is said to have used of the Ten Commandments, "They are a queer lot." In the language of the Psalmist, "They are fearfully and wonderfully made." Generally speaking, animals make less use of sight than man; all those that have been domesticated select their food by the sense of smell and not by sight. The test may be readily made with blind horses, which are unfortunately not as rare as they ought to be. Birds, on the other hand, depend wholly on the sense of sight, which is remarkably acute.[1] In ancient accounts of battles, sieges and pestilence, those gruesome birds that live on corpses are never absent. It may be taken for granted that the problem, How do we see? exercised the ingenuity of the ancient thinkers a great deal. It need not surprise us that they were wide of the mark, seeing that there is as yet no universally accepted theory of vision. But the moderns have learned that color is subjective, whereas the ancients regarded it as objective. Lucretius, who follows the teachings of some of the Greek philosophers, probably of Empedocles, affirms that very thin films are detached from the visible object and impinge upon the eye to produce sight. Aristotle was convinced that there must be some medium between the organ of sight and the object seen by which the sight-process is mediated. Lucretius says that persons afflicted with jaundice see everything yellow because so many atoms of that color fill the orb of sight. He compares the casting away of films or effigies to the cicada that casts off its tunic, or the snake that sheds its glossy vesture and to fire that emits smoke. Much later Locke says: "Since the extension, figure, number and motion of bodies of an observable bigness may be perceived at a distance by the sight, it is evident that some singly imperceptible bodies must come from them to the eye." Lucretius seems to have observed natural phenomena with unusual care for a Roman, but it was rather their more violent aspects, such as thunder and lightning, earthquakes and waterspouts and floods. The phenomena of rain, hail and snow could of course not escape his attention. It has been shown above that the ancients, particularly the Greeks, had a very defective perception of colors and that they had very poor eyes for the beauties of nature as displayed in scenery. It may be interesting to trace briefly the growth of this last sentiment, since it is one of the latest phases of evolution. The Greeks were eminently a social people. They laid

[1] I recently came across the following—how much truth there is in it I do not know: "Red will annoy a turkey-cock as much as a bull, but a sparrow will not let it disturb its mind. But if one shakes a blue rag in front of a caged sparrow's eyes, he will go frantic with disgust. Sparrows, and linnets too, will refuse food offered to them on a piece of blue paper, and dislike the appearance of any one wearing a blue dress. Medium light blue affects them most, but blue serge they scarcely mind at all. Thrushes and blackbirds object to yellow, but will use red or blue dried grasses left about their haunts to build the outer layers of their nests. Yellow grasses they let alone."

great stress upon that urbanity which is acquired only by long association of man with man. Greek pedagogy insists that education shall above all things make the gentleman. Greek thinkers were far more interested in their fellow men than in their irrational companions or in the silent creation. It is true Theocritus, and the much later Dio, praise country life, but they lived in an age that was preeminently one of books. They commend the simple and unsophisticated manners of those who keep aloof from the haunts of men more than they express delight in their rustic surroundings. They do not like nature so much as they dislike man. Among the Romans, Virgil and Horace follow the same course. They either never leave the city or they stay within easy reach of it. They do as did the usurer whom the latter portrays in his much-read and often-translated second Epode. After enumerating the delights of country life and the various vexations of those who have much to do with men, he ends just where he began—by staying in the city. This praise of rural life reads as if written by one who knew but little about it. We find much the same thing in Germany in Gessner's writings and in England in the age of Anne.

Pope declares:

> Happy the man whose wish and care
> A few paternal acres bound;
> Content to breathe his native air
> On his own ground.

Yet he never went farther from London than Virgil or Horace from Rome. We get curious glimpses into the vagaries of taste when we trace even in the barest outline the manifestations of what was supposed to be a love of nature. Virgil's Pastoral poems seem to have been the original inspiration. We can follow their influence in almost every country of Europe from the fifteenth to the seventeenth century, and, to some extent, in the eighteenth. Even the horticultural art was made subservient to this fantastic taste of which Lenotre was the chief apostle. Trees and shrubbery were clipped and trained into artificial forms, and flowers were planted according to geometrical figures. The aristocracy professed a love for nature, but it was nature of a very unnatural sort. It is not until we come to Bloomfield and Crabbe, but especially to Wordsworth, that we find nature and the unsophisticated man receiving a genuine poetical treatment by persons who knew both at first hand and studied them with genuine sympathy. Walter Scott was likewise an ardent lover of nature and of natural scenery. Both his poetry and his prose are evidence. His novels contain many elaborate descriptions of scenery that bear the stamp of verisimilitude. They are the work of a constructive imagination of the highest order. If Xenophon had had an eye for the beauties of mountain and plain, of forest and stream, he would have left upon record his impressions of them rather than the numerous and long speeches he has handed down to posterity, made for the most part 'out

of his own head.' If it be alleged in extenuation that the circumstances under which his notes were taken were ill suited to the careful study of external nature, it is to be said in reply that he observed and recorded what most interested him. His itinerary is so inaccurately, or at least so sparingly, marked that no modern explorer has been able to follow or trace it. In view of the fact that the ancients did not receive as much pleasure from the contemplation of scenery as we moderns, it is probable that they did not regard blindness or failing sight as a very serious misfortune. In Schiller's Tell we have a notable passage describing the frightful misfortune of blindness:

> **Oh! 'tis a noble gift of Heaven,**
> **The gift of sight, each being lives on light,**
> **And all creation feels its gladding power!**
> **The plants themselves turn joyfull to the light:**
> **To die—is nothing—nothing! but to live,**
> **And not to see—is misery indeed!**

The Greeks believed that the power of internal vision was enhanced by lack of bodily sight. This belief was in accordance with the law of compensation held by them. Fortune, good or ill, is always outweighed by its opposite. 'The blind old man of Scio's rocky isle' was supposed to have been blind because his intellectual insight was preternaturally acute and accurate. Tiresias, the most famous seer in Greek legend, is always spoken of as blind. We do not know whether this preternatural acumen was the result of his want of sight or whether the latter was a condition precedent to the former. One of the favorite characters of Greek mythology was Œdipus, spending the sunset of his life in dignified retirement near Athens under the care of his daughter Antigone. In early years he had blinded himself after discovering that he had unwittingly been guilty of incest. The Greeks did but little by artificial light. They were early risers and all reputable people were supposed to retire early. Plato, in his Laws, says the master and mistress of the household should be the first to rise in the morning in order to show a good example to the other members. He further says: "Magistrates who keep awake at night are terrible to the bad whether enemies or citizens and are honored and revered by the temperate, and are useful to themselves." Throughout the entire ancient, medieval and modern world, until within comparatively recent times, the badly lighted or totally dark streets made it a matter of prudence for honest people to go abroad as little as possible after nightfall, especially if they carried or were supposed to carry articles of value. The comparative sameness in the style of clothing gave the footpad the opportunity to replenish his wardrobe at the expense of his fellow without saying, 'By your leave.' We are not told that the man who went down to Jericho was attacked in the night, but we are informed that he was stripped. That the ancients placed a much higher value on worn garments than is done by the moderns is shown by the statement

that the soldiers who kept guard over the body of Christ on the cross cast lots for his raiment. This was the custom at the execution of malefactors.

It is curious that the free Greeks were in the habit of rising early, for, owing to the abundance of slaves, most of them had little compulsory work to perform except when on military expeditions. A law of Solon prohibited teachers from opening school before sunrise or holding it after sunset. To the casual reader this may sound ridiculous. But to many of our older college graduates, it will occur that they were required to attend prayers so early in the morning that they had to be conducted by lamp or candle. An acquaintance of mine who lived near a certain college used to relate that he well remembered hearing young men pass his house in the dark of the morning who, while completing the process of dressing, interspersed the performance with occasional expressions not suitable for ears polite. The mood in which such persons reached their destination was evidently not well suited to the spirit of devotion which those early exercises were supposed to foster.

Many people believe, because they have read in books, that the sight of the Indians was extraordinarily keen, and that they were able to descry objects at a greater distance than was possible for white men. This is an error, if the assertion is to be taken without qualification. All savages have eyes trained to see those things that are necessary to their preservation—game and enemies. Their sight is not by nature more acute than that of the white man, but in some respects it was better trained. The whites who lived among the Indians and were compelled to defend themselves against their enemies saw just as far as their enemies. It may be affirmed as a general principle that there is nothing a civilized man can not do better than a savage. The latter uses his reason to aid his instinct; the former makes his instinct subservient to his reason. It is well known that sailors are able to discern objects at sea at a greater distance than landsmen, but we have to do here with a faculty that any one can acquire. The Indians did just what the whites who lived among them did who subsisted on game and were obliged to be on the constant lookout for enemies. Both had acquired not merely the power to discern objects, but also training in the interpretation of the signification of those objects that came within visible range. It is probable, for reasons given above, that not only the Indians as well as all tribes living on the same social level, but also the backwoodsmen, retained their sight to a more advanced age than is now generally the case; but that the eye of the former was naturally more powerful than that of the present generation or that of men in general is unsupported by trustworthy evidence. There is no doubt that a child born with normal eyes in one of our large cities can see objects just as far off and define them just as accurately with

proper training as a person who never saw a dozen houses together. It is well known, too, that what are sometimes called the lower senses, touch, taste and smell, are often of extraordinary acuteness in civilized man as the result of training. If, therefore, any of the senses of our urban population is feebler than that of the dwellers in the rural districts, it is not due to an inherent weakness, but to improper or injudicious use.

Since it is evident that the ancients, particularly the Greeks, looked upon the external world with emotions very different from the moderns, let us next inquire what means they possessed, if any, for strengthening the sight or aiding defective vision. The problem has been a good deal discussed. Those who believe that some sort of apparatus corresponding to modern eye-glasses has been in use from almost time immemorial rely chiefly upon inference, since hardly any direct evidence is forthcoming. It is held by some investigators that the very large number of seal rings and seal cylinders, both intaglios and cameos, dating from the remotest times found in the Babylonian tombs, must be accepted as proof positive that the art of cutting the hardest precious and other stones was a regular business in that part of the world, and that this could not have been carried on without some kind of magnifying lenses. That work of this sort could be performed only by persons of exceptionally keen eyesight is beyond question: the inference drawn from modern experience is logical. Yet in the absence of objects which might reasonably be expected to be forthcoming, we are constrained to render the verdict 'not proven.' So far as we have direct testimony, it is all adverse, if the expression be admissible. It is generally held that the first mention of magnifying glasses is found in an Arab writer of the eleventh century. Roger Bacon speaks of glasses that correct refraction. The epitaph of a certain Salvinus Armatus in Florence names him as the inventor of spectacles, although it is also said of the monk Alexander of Spina, that he made use of eyeglasses. In the year 1488 makers of spectacles are mentioned in Nuremberg. There is a passage in Scott's 'Quentin Durward' that represents Lord Crawford with spectacles on his nose, and the remark is added that the invention was recent. That artificial aids to sight are modern is also rendered probable from the lack of a word inherited from antiquity to designate the apparatus. The English word 'spectacle' is still used in a sense that differs but little from its Latin parent: it is something to look at, a stage-play, then the theater itself. But the earliest English 'spectacle' is used for spy-glass. It is thence probable that our plural 'spectacles' originally meant a pair of spy-glasses, a sort of anticipated binocular. The French *spectacle* still has its original Latin meaning, the form of the word being but slightly changed. On the other hand, in the German and Scandinavian languages, *Spektakel* is equivalent to what we call a 'rumpus.' But

Brille (spectacles) is from beryllus, the Latin name of a transparent stone. The French *besicles* also point to beryl. *Bericle* is an earlier form of *besicle* for 'besiculum,' a little beryl. In some of the French dialects the first syllable *ber-* is still preserved, but the Parisian word for spectacles is *besicles*, in which the original *r* has been changed to *s*, according to a phonetic law traceable in other words also. The Spaniards, Italians and Russians have each a native word to designate this article of common use.

There is a passage in Pliny that is usually cited as evidence that something akin to spectacles must have been in use at least in his time. He relates that the Emperor Nero used a precious stone which he calls 'smaragdus,' generally translated 'emerald,' through which he was accustomed to gaze on the gladiatorial combats; or rather, this is what he seems to say. There is, however, little doubt that Dr. Magnus, the latest author to examine the passage critically, is right in holding that it means no more than that the emperor was in the habit of gazing upon an emerald which he used to carry with him for the purpose of resting his eyes when they became tired looking upon shows that were interesting to him. This view is rendered the more probable from the belief of antiquity that green has a restful effect upon the eyesight.

Contrivances for bringing the rays of the sun to a focus in order to produce combustion have been employed almost from time immemorial. A curious proposal bearing on this point is made by Aristophanes in his comedy of the 'Clouds.' Strepsiades, the hero of the play, is greatly harassed with debts and has not the wherewithal to pay. He therefore proposes to his master to get a stone at some chemist's shop of the kind with which they kindle fire, and when the clerk is entering the suit, to stand at some distance and melt it out. As the writing tablets then in use were probably thin boards covered with a still thinner coating of wax on which the writing was done with a pointed instrument, it would not require great heat to effect the purpose. Besides, if, as seems to have been the case and custom, burning-glasses were used to kindle fires, they must have been of considerable size even in a country like Greece where the sun shines very hot most of the year. Moreover, we are told, they were kept in the chemists' shops for this purpose. If by any mishap the sacred fire watched over by the Vestal Virgins in Rome went out, it was rekindled by means of a burning-glass. Polybius, when speaking of the siege of Syracuse by the Romans, B.C. 214, relates that they were unable to take it from the side of the sea because of the engines employed against them by Archimedes, unquestionably the greatest mechanician of the ancient world. Says he: "So true is it that one man and one intellect properly qualified for the particular undertaking is a host in himself and of wonderful efficacy." The Romans were confident that they could take the city 'if one old man could be got rid of.' He

might have added with equal truth that when a man appears in a world wholly unprepared to comprehend him, not only are his thoughts neglected, but his discoveries forgotten. The story that Archimedes set the ships of the Romans on fire by means of burning-glasses is not found in any author who lived near his time. Moreover, the captains of the vessels would hardly be so obliging as to hold their vessels stationary in order that the old philosopher might work his will on them. Yet the marvelous feats he accomplished on the same occasion and vouched for by credible witnesses are scarcely less incredible. It may be accepted as certain that Archimedes produced wonderful effects by means of his lenses, whether they were made of glass or of some other material. That the ancients as late as the age of Plutarch knew nothing of spectacles is clear from the negative testimony of this writer, whose works might be superscribed 'Concerning all Things and Some Others.' In one of his table talks he tries to explain why old people, when reading, hold the book at some distance from the eyes. He finds the reason to lie in Plato's theory of vision, which he also holds. This philosopher maintained, in common with almost all the thinkers of antiquity, that sight is produced by a sort of fluid substance passing from the visible object to the eye, somewhat in the shape of a cone, the eye being the apex. When the organ becomes weakened by age this attenuated substance is too intense to permit normal vision; so in order to weaken it the object must be held farther away. He finds a confirmation of this theory in the habits of those animals that seek their prey by night when their sight is most acute. The fluid emanating from the object is too strong to be properly commingled with the power of vision, as he expresses it, possessed by these animals, but is so weakened and diluted by the surrounding darkness as to enable them to see at their best. This may seem to us very puerile; it ceases to be so when we remember that to this day no one has been able to answer the question, How do we see?

Though the art of making glass of certain kinds is very old, spectacles had to wait on the discovery or invention of some method that would produce it perfectly transparent. Specimens of glass have been found in the Egyptian tombs that are more than four thousand years old, and glass bottles are represented on tombs at least fifteen hundred years earlier. In Mesopotamia the art of making glass has been traced for at least two thousand years B. C. But all the glass of antiquity was of inferior quality and was almost useless for purposes where the rays of light were to be transmitted unbroken and with undiminished energy. Mirrors were also made in Egypt thousands of years before the christian era. The materials used were obsidian, metal, zinc and silver. Glass mirrors are mentioned by Pliny, but as they were neither perfectly plane nor foliated they gave back a very imperfect image and were not much esteemed. The word translated

'glass' in King James's version is not as clear as in some of the later renderings. The passage in the First Epistle to the Corinthians if read: "As yet we see things dimly, reflected as in a mirror, but then face to face," makes the sense plain. As looking-glasses, to use this term by anticipation, were generally made of steel or some other metal, they readily became tarnished, even when of the best quality; hence the man who beheld his face 'in a glass' rarely got a distinct image, and thus would readily forget the lineaments of his countenance. That window glass, such as is now in common use, was slow to gain currency is shown by the little panes in many old buildings in Europe. They are usually round or nearly so, and so small that one of them can easily be held between the tips of the fingers and the thumb. That this form of window glass first came into vogue in Germany is evident from the name disk (Scheibe) by which a pane of glass is still designated, no matter what its shape.

That ancient customs are still practised by primitive tribes is interestingly shown by the two following incidents. In the Iliad we are told that when Asklepias 'saw the wound where the bitter arrow had lighted he sucked out the blood,' and so forth. In his recent work on the Australian aborigines, John Mathew informs the reader that the doctor or sacred man made a practise of sucking the part affected. He then proceeds: "There seems to be some efficacy in the sucking, for a friend of mine who was suffering severely from an inveterate, inflamed eye allowed a black 'doctor' to mouth the eyeball, and the result of the treatment was immediate relief and speedy cure." A further parallelism between the rise and practise of the healing art and the priestly class, although in Greece the connection was less close than elsewhere and did not long continue, is shown by this extract.

The reading habit is essentially modern and may be said to date from the rise of periodicals, comparatively few of which are more than half a century old. The invention of spectacles and that of printing were very nearly coeval. Until that date literary instruction was largely a matter of dictation, repetition and memorizing, as is still the case in many parts of the world. Among the ancient Greeks and Romans the memory was trained to a far greater extent than with us. In the literature of the former there is constantly evident a sort of distrust of the written page. It could not reflect the vivifying power of the living voice. It seems to have been a common thing for Greek youths to learn Homer by heart, huge as the task would be to us. Knowledge was to be elicited by discussion, by the dialectic method, by question and answer. Intellectual training was almost exclusively rhetorical. Taking into consideration, therefore, the fact that eyes were not needed for the manufacture and use of instruments of precision and that the printed page did not exist, we can easily understand that spectacles were not greatly missed.

THE CLASSIFICATION OF THE ARTS

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THE conventional classification of the arts into useful, mechanic or industrial, and liberal, polite or fine is unscientific. It will not stand before even a superficial examination. Fine and useful are by no means mutually exclusive terms. The fine arts are useful, and the useful arts should be fine. The art that paints a picture or chisels a statue satisfies the desire for beauty. It is, therefore, useful for the same reason that cooking or farming or making shoes is useful. All that the word useful implies is satisfaction of desire, and this is the object of all the arts. On the other hand, the word fine, as applied to art, does not signify the absence of utility, but merely that the art has been brought to a certain degree of perfection (polite-polished), and that its practise is associated with gentility. There is no inherent reason why a useful art may not become a fine art. Obviously, then, the division of the arts into fine and useful is not dichotomous. One might as well divide the sciences into practical and interesting.

But are not the fine arts to be distinguished from the useful arts on the ground that the former involve the use of the imagination and the realization of the beautiful? It is true, of course, that the fine arts are *par excellence* the imaginative arts, and that they minister chiefly to the esthetic sense. Still, even this fact does not distinguish them wholly from the useful or industrial arts. Intelligence, imagination and pleasure are elements to be found in all the arts. Art really implies intelligence, and it is clear that imagination and pleasure may enter into invention as well as into the so-called creative arts.

What, then, is the basis of the familiar classification? It is the relative historical circumstances under which the respective arts originated and have been developed. The useful, mechanic or industrial arts are allied to productive labor, and their history is the history of labor; while the liberal, polite or fine arts have always been associated with leisure and culture.

Now productive labor, as everybody knows who is in the least familiar with industrial history, was originally imposed by the conquering upon the conquered. It was a function of the slave. Hence to labor has attached the odium of slavery. A life of productive labor was, in the earlier history of mankind, *prima facie* evidence of subjection and inferiority. This was true not only among barbarians, but

also among the peoples most highly civilized. In Athens, for instance, all work was assigned to slaves. Among the nobility in Lacedemonia the women were not allowed to spin or weave for fear of degrading their rank. In Rome the trades were called the dirty arts (*sordidæ artes*). Plato and Cicero were alike in regarding the useful occupations as degrading. Even the 'chosen people' imagined that to eat one's bread in the sweat of one's face is one of the severest curses, while people of modern times do not fully realize that under fair conditions it is a blessing, and that under almost any conditions it is better than to eat one's bread in the sweat of another's face. With such ideas of labor it is not surprising that the arts identified with it, or associated with it in thought, should be put in a class by themselves.

On the other hand, leisure being originally, as it is now in some quarters, a badge of respectability, the arts of the leisure class have naturally partaken of this distinction and been regarded as superior to the useful arts. The leisure class could not display its freedom from toil more aptly than by pursuing arts not essential to physical existence. Hence, while all the arts were originally useful, the arts to which members of the leisure class were drawn were those least obviously so. They *selected* those arts which could be pursued only by those who could command their own time. Hence, painting, sculpture, music, poetry and the like were properly called the elegant, that is, the elected, arts, and they soon came to hold the same relation in thought to the useful arts as the leisure class held to the laboring class.

This, then, is the explanation of the long-accepted division of the arts into fine and useful: the monopolization of the fine arts by the leisure class, and the compulsory practise of the useful arts by the slave, the serf and the wage laborer. It is a division based primarily upon a class distinction. The fine arts, speaking generally, involve a greater play of the imagination, a freer expression of individuality, more pleasure than the useful arts, but this is due to the greater leisure and freedom of those who monopolized them as well as to the nature of those arts themselves. If laborers in the industrial arts had more freedom, culture and leisure, and the conditions of their work were made conducive to pleasure, these arts would become fine arts; not so 'fine' as painting and sculpture, perhaps, but fine arts, nevertheless. 'Work without art,' said Ruskin, and by this I suppose he meant work unaccompanied by pleasure, 'is brutality.' But work ought not to be divorced from art. The joy and beauty now associated with the fine arts must become elements of the useful arts as well. "Beauty must come back to the useful arts," said Emerson, "and the distinction between the fine and the useful arts be forgotten. If history were truly told, if life were nobly spent, it would no longer be easy or possible to

distinguish the one from the other. In nature all is useful, all is beautiful."[1]

We submit, then, that the commonly accepted classification of the arts is an arbitrary one. Its foundation, the supposedly ignoble character of productive labor, is a false idea. Labor, not leisure, is the real badge of dignity. 'The stone which the builders refused is become the headstone of the corner.' Hence the old classification of the arts, a classification which tends to disparage labor, is an anachronism, and an impertinence. It is, in a way, a gratuitous reflection upon the laboring class.

Before proceeding to reclassify the arts, let us carefully define the scope of art. The word art usually suggests the fine arts. "'Work of art' to most people," says Huxley, "means a picture, a statue, or a piece of bijouterie; by way of compensation 'artist' has included in its wide embrace cooks and ballet girls, no less than painters and sculptors."[2] The word art properly includes 'all the works of man's hands, from a flint implement to a cathedral or a chronometer.' It embraces all phenomena in which intelligence plays the part of conscious and immediate cause. The supplement of art is nature. Art includes everything not embraced by nature.

The field of the arts being thus defined, we may now construct our classification.

All arts are alike in this—their medium is matter. No art can free itself wholly from material things. Some arts, as music and poetry, may seem to do so, for the ideal elements of these arts predominate to such an extent that we forget the material by which they are made manifest—writing and printing materials, musical instruments and sound waves. No matter how idealistic an art may be, it must still deal with matter.

This being the case, a logical classification of the arts may be based upon a classification of material phenomena. And if this latter is an evolutionary classification, that is, if it proceeds from the simple to the complex, the resulting classification of the arts will be in the order of complexity and potential utility. It will also be a classification in which each art will be a means to those above it, that is, a classification of superiority and subordination.

Now one of the most obvious divisions of the material world is into the inorganic, the organic and the superorganic. From the standpoint of evolution these divisions rank in the order named—the organic is higher than the inorganic, and the superorganic higher than the organic. Each division furnishes the material upon which is exercised

[1] 'Essays,' First Series, Essay XII., Art.

[2] 'Evolution and Ethics, and Other Essays,' authorized edition, New York, 1899, p. 10, foot-note.

a special class of arts. There are arts which deal with wood, stone and iron (lifeless elements), arts that deal with living things, and arts that deal with organized groups of men, or societies. Hence there are three grand divisions of the arts corresponding to the three grand divisions of the material world. Simplifying our terminology, we may call them the physical arts, the vital arts and the social arts.

The physical arts are relatively the lowest. The material upon which they are employed is passive. It 'stays put.' The principles underlying these arts are extremely simple. The mechanical principles, for instance, are seven in number. They may indeed be reduced to two—the lever and the inclined plane. Historically probably, as well as analytically, the art of making and using tools comes first. The primitive man who chipped his arrow-head from a piece of flint, and fashioned the shaft of his arrow from a stick of wood, employed art. He was an artist. If in the practise of his art he manifested no sense of beauty, it was due to the pressing demands of the more imperative desires rather than to the absence of the esthetic sense. What birds and beasts, and even insects, possess must have been present in the lowest of men. Archeology shows that even the cave-dweller tried his hand occasionally at the purely decorative arts. But the first arts were the hand arts—manufacture, in the strict sense of that word.

As intelligence increased, and inventive genius was applied, hand-making grew into machine-making. The machine is a combination of tools in the operation of which a natural force, like wind, water, steam or electricity, is usually employed. The machine arts are more complex than the hand arts. Their social potentiality is greater. Their object, like that of the hand arts, is not necessarily the production of articles of vulgar utility only. It may be idealistic in the highest degree. The various fine arts must fall under one division or the other. Hand-making (manufacture) and machine-making (machino-facture) completely cover the realm of the physical arts. Under the first are the manual occupations (handicrafts), and under the second the mechanical occupations, imperfectly designated 'the trades.'

Now, the physical arts that minister to the vulgar wants, or needs, of mankind have reached a high degree of perfection. They are to-day the theater for the display of the highest reaches of inventive genius. A watch, a locomotive, a printing-press, are marvels of ingenuity. We do not wonder that untutored men have worshiped a watch as a superior being. A printing-press, working automatically, will print, fold and deliver twelve thousand twenty-four-page papers in an hour. Machines in almost every industry turn out articles which in quantity, regularity and delicacy of form could not possibly be produced by hand. But the object of these arts has been quantity rather than quality, mercantile utility rather than beauty. Salability has been their main

consideration. They have been the instruments of trade and gain, rather than the ministers of joy and life. They have thus been degraded. They are the Cinderella of the household of art. None the less they are noble; and when clothed in beauty, as some day, let us hope, they will be, they will win their full share of admiration and devotion. The repulsion which some profess to feel toward the machine arts is based upon a misconception. It is not these arts which should excite disdain: it is the purpose for which they are employed and the conditions under which they are practised. They could free men from drudgery if properly used; they outrank the genii of fable in serving their master; and they are not in themselves incompatible with pleasure and beauty. But as industrial conditions are to-day, men are not the masters of the machine. They are enslaved by it. Machinery has more slaves than any dominant class ever possessed. Thus it has been, and thus it will be as long as men are 'an appendage to profit-grinding.' Once free men from the machine, give them leisure and culture, and the machine arts will become fine arts. Under normal conditions the element of the beautiful would manifest itself in all work, mechanical or manual, because man is a beauty-loving animal.

It appears, then, that the arts now known as the fine arts must, in our present classification, be distributed among the handicrafts and the mechanical occupations, since they have been selected out because of their idealistic character. They are physical arts, because, like all such arts, they realize the ideal by the exercise of manual or mechanical operations upon brute matter. The artist who paints a picture employs pigment and canvas and brush. To be sure he is supposed to 'mix his paint with brains,' but there is nothing essentially unique in this. Mortar should be so mixed—and dough. The sculptor uses stone and a chisel. The mechanical part of his work is turned over to the machine, from which he himself is free. His art differs in no inherent and absolute respect from that of the industrial artist. Carving a statue to please the eye ought not to differentiate the 'artist' from the laborer who carves a chair to relieve us of 'that tired feeling.' If the one act is accompanied by pleasure, and a manifestation of the beautiful, while the other is not, it is due to factitious circumstances.

It is not to be denied, of course, that the fine arts are the most highly cultivated of all the arts. Their possibilities have, perhaps, been more completely realized than those of the other arts. Certainly this is true with respect to the vital and the social arts. They have drawn to themselves much of the talent freed from the grosser forms of labor. They have touched the highest levels of skill in execution, and of idealistic conception. Zeuxis, it is said, imitated nature so successfully that the birds pecked at his painted grapes, while Parrhasius, his Athenian rival, deceived with his pictured curtain even the practised eye of

Zeuxis himself. Every museum *des beaux artes* evidences lofty flights in the realm of the ideal. Some profess to believe that the climax of art has been reached, that Grecian art will never be surpassed. This is a gratuitous assumption. The soil of art is freedom, leisure and culture; its light and warmth and moisture, appreciation. If men were freed from grinding toil, if the industrial arts had become fine arts, and art appreciation were a common heritage, the growth of even the more imaginative arts would receive an impetus hitherto unfelt, and achieve a development as yet unrealized.

We have now analyzed the physical arts, the arts which deal with non-living matter. They are divided into manufacture, which embraces the handicrafts, and machinofacture, which includes the mechanical occupations. There is no need of a third class to embrace the fine arts, since these are at bottom manual or mechanical, and their fineness is due to the circumstances under which they have been cultivated. Ideally all arts are fine. We now pass to the vital arts.

The world of life is divided into plants and animals. The arts corresponding to these two divisions are the botanical and the zoological. The botanical arts realize the ideal in plant life; the zoological, in animal life. To the former belong agriculture, horticulture, and the like, and to the latter the domestication, breeding and training of animals, and the education of man. It might be more complimentary and gratifying to the human animal if the arts pertaining to his development were given a class by themselves. This may be done, if it is insisted upon. They would be called, of course, the anthropological arts.

Now, the vital arts, dealing as they do with a higher because more complex form of matter, are superior to the physical arts. It will seem strange and illogical at first thought to find farming ranked above music, and gardening above painting. And there is, of course, an element of absurdity in it if we think of the botanical arts as they are usually practised. They are empirical. Their possibilities of use and beauty have only begun to be appreciated. They bear about the same relation to what they might be, as a chant of the Igorrotes does to a Wagnerian opera. There is not a nation on the globe that has given, or is now giving, as much scientific attention to farming as to fighting. Hence the farmer is still a 'hayseed,' and the fighter a tailor's model. But if we think of these arts as they might become—as sustaining a populous world and clothing it with new forms of life and beauty—our estimate will change. If, as we read, Mr. Burbank has developed new species of flowers and fruit, and has produced a spineless cactus which is to be the means of reclaiming the arid regions of the west, he has revealed some of the possibilities of the botanical arts, and done much to remove the stigma that has attached to the cultivation of the

soil. Breeders and fanciers are showing what can be done to mold animal life into preconceived forms. They "habitually speak of an animal's organization," says Darwin, "as something plastic, which they can model almost as they please." "It would seem," said Lord Somerville, "as if they had chalked out upon a wall a form perfect in itself, and then had given it existence."[3] Is it less difficult to fashion the ideal in flesh than in clay? The fine arts have been called the 'creative arts.' But the botanical and zoological arts, which are capable of bringing into existence new forms of life, ideal forms, differing in size, shape, color and character from anything that nature has produced, are also creative arts. They continue and supplement the work of the Creator. There seems no absurdity, then, in ranking above the art that paints a flower the art that can produce one; above the art that beguiled the birds, the art that can change the leopard's spots.

At the head of the vital arts is the art which seeks to realize the ideal in the life and character of individual men. Man is an animal, a paragon, if you please, and the 'beauty of the world,' but still an animal. The arts devoted to his physical, mental and moral improvement are, strictly speaking, zoological. They are the highest of the vital arts because they deal with the highest form of life, and outrank all below them in possibilities. The ideal man realized in the flesh, which is the object of these arts, would exceed in beauty and beneficent influence anything that is possible to the painter's brush or the sculptor's chisel. The totality of these arts may be embraced by the word education.

Education employs all lower arts as means. It rests upon them and requires a knowledge of their principles. To educate demands the highest type of mind. It is an art which the world has never properly estimated or appreciated. When ranked as an art at all it has been placed below the fine arts, whereas, when made a fine art itself, it is immeasurably above them. To be sure, there are few who have made it such. The great educational artists may be counted on one's fingers. Each of these men has been as one born out of time. But when the art of education is duly appreciated the world will find a place in its Temple of Fame for such artists as Pestalozzi and Froebel, Herbart and Horace Mann, and the other great teachers who have striven to make the word flesh that it might dwell among men. Education should always be, and should always have been, a fine art.

We now come to the third and last division of the arts, the social arts. The ultimate end of all the arts is a perfected humanity. Hence, in one sense, all the arts are social arts. Here, however, we include only the arts which have for their immediate end the improvement of society, which deal with society as the next lower arts deal with the individ-

[3] See Darwin, 'Origin of Species,' Chap. I.

ual—man, lower animal or plant. The social arts are in reality one art. They are the art of employing all other arts in the realization of an ideal social conception. This art might also be called education, since we speak of the education of the race as well as the education of the individual. It might be called government, if that word were not vitiated by its associations. Professor Lester F. Ward employs the word sociocracy. "This general social art," he says, "the scientific control of the social forces by the collective mind of society for its advantage, in strict homology with the practical arts of the industrial world, is what I have hitherto given the name Sociocracy."[4] Call it what we may, this social art is the highest of all the arts. Its end is a perfected humanity. In realizing this end it utilizes all other arts. It is the art of arts. Its application requires the maximum of intelligence and skill. Its potentialities are as yet undreamed of.

The main divisions and subdivisions of the arts having now been passed briefly in review, it will be helpful to bring them together in tabular form. They will stand as follows:

Art	1. Physical	Manufacture	Handicrafts.
		Machinofacture	Mechanical occupations.
	2. Vital	Botanical	Agriculture.
			Horticulture, etc.
		Zoological	Domestication, breeding and training.
			Education.
	3. Social	Sociocracy.	

[4] 'Outlines of Sociology,' New York, 1898, p. 292.

THE VALUE OF SCIENCE

Chapter IX. The Future of Mathematical Physics

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The Principles and Experiment.—In the midst of so much ruin, what remains standing? The principle of least action is hitherto intact, and Larmor appears to believe that it will long survive the others; in reality, it is still more vague and more general.

In presence of this general collapse of the principles, what attitude will mathematical physics take? And first, before too much excitement, it is proper to ask if all that is really true. All these derogations to the principles are encountered only among infinitesimals; the microscope is necessary to see the Brownian movement; electrons are very light; radium is very rare, and one never has more than some milligrams of it at a time. And, then, it may be asked whether, besides the infinitesimal seen, there was not another infinitesimal unseen counterpoise to the first.

So there is an interlocutory question, and, as it seems, only experiment can solve it. We shall, therefore, only have to hand over the matter to the experimenters, and, while waiting for them to finally decide the debate, not to preoccupy ourselves with these disquieting problems, and to tranquilly continue our work as if the principles were still uncontested. Certes, we have much to do without leaving the domain where they may be applied in all security; we have enough to employ our activity during this period of doubts.

The Rôle of the Analyst.—And as to these doubts, is it indeed true that we can do nothing to disembarrass science of them? It must indeed be said, it is not alone experimental physics that has given birth to them; mathematical physics has well contributed. It is the experimenters who have seen radium throw out energy, but it is the theorists who have put in evidence all the difficulties raised by the propagation of light across a medium in motion; but for these it is probable we should not have become conscious of them. Well, then, if they have done their best to put us into this embarrassment, it is proper also that they help us to get out of it.

They must subject to critical examination all these new views I have just outlined before you, and abandon the principles only after having made a loyal effort to save them. What can they do in this sense? That is what I will try to explain.

It is a question before all of endeavoring to obtain a more satisfactory theory of the electrodynamics of bodies in motion. It is there especially, as I have sufficiently shown above, that difficulties accumulate. It is useless to heap up hypotheses, we can not satisfy all the principles at once; so far, one has succeeded in safeguarding some only on condition of sacrificing the others; but all hope of obtaining better results is not yet lost. Let us take, then, the theory of Lorentz, turn it in all senses, modify it little by little, and perhaps everything will arrange itself.

Thus in place of supposing that bodies in motion undergo a contraction in the sense of the motion, and that this contraction is the same whatever be the nature of these bodies and the forces to which they are otherwise subjected, could we not make a more simple and natural hypothesis? We might imagine, for example, that it is the ether which is modified when it is in relative motion in reference to the material medium which penetrates it, that, when it is thus modified, it no longer transmits perturbations with the same velocity in every direction. It might transmit more rapidly those which are propagated parallel to the motion of the medium, whether in the same sense or in the opposite sense, and less rapidly those which are propagated perpendicularly. The wave surfaces would no longer be spheres, but ellipsoids, and we could dispense with that extraordinary contraction of all bodies.

I cite this only as an example, since the modifications that might be essayed would be evidently susceptible of infinite variation.

Aberration and Astronomy.—It is possible also that astronomy may some day furnish us data on this point; she it was in the main who raised the question in making us acquainted with the phenomenon of the aberration of light. If we make crudely the theory of aberration, we reach a very curious result. The apparent positions of the stars differ from their real positions because of the earth's motion, and as this motion is variable, these apparent positions vary. The real position we can not ascertain, but we can observe the variations of the apparent position. The observations of the aberration show us, therefore, not the earth's motion, but the variations of this motion; they can not, therefore, give us information about the absolute motion of the earth.

At least this is true in first approximation, but the case would be no longer the same if we could appreciate the thousandths of a second. Then it would be seen that the amplitude of the oscillation depends not alone on the variation of the motion, a variation which is well known, since it is the motion of our globe on its elliptic orbit, but on the mean value of this motion, so that the constant of aberration would not be quite the same for all the stars, and the differences would tell us the absolute motion of the earth in space.

This, then, would be, under another form, the ruin of the principle of relativity. We are far, it is true, from appreciating the thousandth of a second, but, after all, say some, the earth's total absolute velocity is perhaps much greater than its relative velocity with respect to the sun. If, for example, it were 300 kilometers per second in place of 30, this would suffice to make the phenomenon observable.

I believe that in reasoning thus one admits a too simple theory of aberration. Michelson has shown us, I have told you, that the physical procedures are powerless to put in evidence absolute motion; I am persuaded that the same will be true of the astronomic procedures, however far precision be carried.

However that may be, the data astronomy will furnish us in this regard will some day be precious to the physicist. Meanwhile, I believe that the theorists, recalling the experience of Michelson, may anticipate a negative result, and that they would accomplish a useful work in constructing a theory of aberration which would explain this in advance.

Electrons and Spectra.—This dynamics of electrons can be approached from many sides, but among the ways leading thither is one which has been somewhat neglected, and yet this is one of those which promise us the most surprises. It is movements of electrons which produce the lines of the emission spectra; this is proved by the Zeeman effect; in an incandescent body what vibrates is sensitive to the magnet, therefore electrified. This is a very important first point, but no one has gone farther. Why are the lines of the spectrum distributed in accordance with a regular law? These laws have been studied by the experimenters in their least details; they are very precise and comparatively simple. A first study of these distributions recalls the harmonics encountered in acoustics; but the difference is great. Not only are the numbers of vibrations not the successive multiples of a single number, but we do not even find anything analogous to the roots of those transcendental equations to which we are led by so many problems of mathematical physics: that of the vibrations of an elastic body of any form, that of the Hertzian oscillations in a generator of any form, the problem of Fourier for the cooling of a solid body.

The laws are simpler, but they are of wholly other nature, and to cite only one of these differences, for the harmonics of high order, the number of vibrations tends toward a finite limit, instead of increasing indefinitely.

That has not yet been accounted for, and I believe that there we have one of the most important secrets of nature. A Japanese physicist, M. Nagaoka, has recently proposed an explanation; according to him, atoms are composed of a large positive electron surrounded by a

ring formed of a very great number of very small negative electrons. Such is the planet Saturn with its rings. This is a very interesting attempt, but not yet wholly satisfactory; this attempt should be renewed. We will penetrate, so to speak, into the inmost recess of matter. And from the particular point of view which we to-day occupy, when we know why the vibrations of incandescent bodies differ thus from ordinary elastic vibrations, why the electrons do not behave like the matter which is familiar to us, we shall better comprehend the dynamics of electrons and it will be perhaps more easy for us to reconcile it with the principles.

Conventions Preceding Experiment.—Suppose, now, that all these efforts fail, and, after all, I do not believe they will, what must be done? Will it be necessary to seek to mend the broken principles by giving what we French call a *coup de pouce?* That evidently is always possible, and I retract nothing of what I have said above.

Have you not written, you might say if you wished to seek a quarrel with me—have you not written that the principles, though of experimental origin, are now unassailable by experiment because they have become conventions? And now you have just told us that the most recent conquests of experiment put these principles in danger.

Well, formerly I was right and to-day I am not wrong. Formerly I was right, and what is now happening is a new proof of it. Take, for example, the calorimetric experiment of Curie on radium. Is it possible to reconcile it with the principle of the conservation of energy? This has been attempted in many ways; but there is among them one I should like you to notice; this is not the explanation which tends to-day to prevail, but it is one of those which have been proposed. It has been conjectured that radium was only an intermediary, that it only stored radiations of unknown nature which flashed through space in every direction, traversing all bodies, save radium, without being altered by this passage and without exercising any action upon them. Radium alone took from them a little of their energy and afterward gave it out to us in various forms.

What an advantageous explanation, and how convenient! First, it is unverifiable and thus irrefutable. Then again it will serve to account for any derogation whatever to Mayer's principle; it answers in advance not only the objection of Curie, but all the objections that future experimenters might accumulate. This new and unknown energy would serve for everything.

This is just what I said, and therewith we are shown that our principle is unassailable by experiment.

But then, what have we gained by this stroke? The principle is intact, but thenceforth of what use is it? It enabled us to foresee that in such or such circumstance we could count on such a total

quantity of energy; it limited us; but now that this indefinite provision of new energy is placed at our disposal, we are no longer limited by anything; and, as I have written in 'Science and Hypothesis,' if a principle ceases to be fecund, experiment without contradicting it directly will nevertheless have condemned it.

Future Mathematical Physics. This, therefore, is not what would have to be done; it would be necessary to rebuild anew. If we were reduced to this necessity, we could moreover console ourselves. It would not be necessary thence to conclude that science can weave only a Penelope's web, that it can raise only ephemeral structures, which it is soon forced to demolish from top to bottom with its own hands.

As I have said, we have already passed through a like crisis. I have shown you that in the second mathematical physics, that of the principles, we find traces of the first, that of central forces; it will be just the same if we must know a third. Just so with the animal that exuviates, that breaks its too narrow carapace and makes itself a fresh one, under the new envelope one will recognize the essential traits of the organism which have persisted.

We can not foresee in what way we are about to expand; perhaps it is the kinetic theory of gases which is about to undergo development and serve as model to the others. Then the facts which first appeared to us as simple thereafter would be merely resultants of a very great number of elementary facts which only the laws of chance would make cooperate for a common end. Physical law would then assume an entirely new aspect; it would no longer be solely a differential equation, it would take the character of a statistical law.

Perhaps, too, we shall have to construct an entirely new mechanics that we only succeed in catching a glimpse of, where, inertia increasing with the velocity, the velocity of light would become an impassable limit. The ordinary mechanics, more simple, would remain a first approximation, since it would be true for velocities not too great, so that the old dynamics would still be found under the new. We should not have to regret having believed in the principles, and even, since velocities too great for the old formulas would always be only exceptional, the surest way in practise would be still to act as if we continued to believe in them. They are so useful, it would be necessary to keep a place for them. To determine to exclude them altogether would be to deprive oneself of a precious weapon. I hasten to say in conclusion that we are not yet there, and as yet nothing proves that the principles will not come forth from out the fray victorious and intact.[1]

[1] These considerations on mathematical physics are borrowed from my St. Louis address.

PART THIRD. The Objective Value of Science

Chapter X. Is Science Artificial?

§ 1. *The Philosophy of M. LeRoy*

There are many reasons for being sceptics; should we push this scepticism to the very end or stop on the way? To go to the end is the most tempting solution, the easiest, and that which many have adopted, despairing of saving anything from the shipwreck.

Among the writings inspired by this tendency it is proper to place in the first rank those of M. LeRoy. This thinker is not only a philosopher and a writer of the greatest merit, but he has acquired a deep knowledge of the exact and physical sciences, and even has shown rare powers of mathematical invention. Let us recapitulate in a few words his doctrine, which has given rise to numerous discussions.

Science consists only of conventions, and to this circumstance solely does it owe its apparent certitude; the facts of science and, *a fortiori*, its laws are the artificial work of the scientist; science therefore can teach us nothing of the truth; it can only serve us as rule of action.

Here we recognize the philosophic theory known under the name of nominalism; all is not false in this theory; its legitimate domain must be left it, but out of this it should not be allowed to go.

This is not all; M. LeRoy's doctrine is not only nominalistic; it has besides another characteristic which it doubtless owes to M. Bergson, it is anti-intellectualistic. According to M. LeRoy, the intellect deforms all it touches, and that is still more true of its necessary instrument 'discourse.' There is reality only in our fugitive and changing impressions, and even this reality, when touched, vanishes.

And yet M. LeRoy is not a sceptic; if he regards the intellect as incurably powerless, it is only to give more scope to other sources of knowledge, to the heart for instance, to sentiment, to instinct or to faith.

However great my esteem for M. LeRoy's talent, whatever the ingenuity of this thesis, I can not wholly accept it. Certes, I am in accord on many points with M. LeRoy, and he has even cited, in support of his view, various passages of my writings which I am by no means disposed to reject. I think myself only the more bound to explain why I can not go with him all the way.

M. LeRoy often complains of being accused of scepticism. He could not help being, though this accusation is probably unjust. Are not appearances against him? Nominalist in doctrine, but realist at heart, he seems to escape absolute nominalism only by a desperate act of faith.

The fact is that anti-intellectualistic philosophy in rejecting

analysis and 'discourse,' just by that condemns itself to being intransmissible, it is a philosophy essentially internal, or, at the very least, only its negations can be transmitted; what wonder then that for an external observer it takes the shape of scepticism?

Therein lies the weak point of this philosophy; if it strives to remain faithful to itself, its energy is spent in a negation and a cry of enthusiasm. Each author may repeat this negation and this cry, may vary their form, but without adding anything.

And yet, would it not be more logical in remaining silent? See, you have written long articles; for that, it was necessary to use words. And therein have you not been much more 'discursive' and consequently much farther from life and truth than the animal who simply lives without philosophizing? Would not this animal be the true philosopher?

However, because no painter has made a perfect portrait, should we conclude that the best painting is not to paint? When a zoologist dissects an animal, certainly he 'alters it.' Yes, in dissecting it, he condemns himself to never know all of it; but in not dissecting it, he would condemn himself to never know anything of it and consequently to never see anything of it.

Certes, in man are other forces besides his intellect, no one has ever been mad enough to deny that. The first comer makes these blind forces act or lets them act; the philosopher must *speak* of them; to speak of them, he must know of them the little that can be known, he should therefore *see* them act. How? With what eyes, if not with his intellect? Heart, instinct, may guide it, but not render it useless; they may direct the look, but not replace the eye. It may be granted that the heart is the workman, and the intellect only the instrument. Yet is it an instrument not to be done without, if not for action, at least for philosophizing. Therefore a philosopher really anti-intellectualistic is impossible. Perhaps we shall have to declare for the supremacy of action; always it is our intellect which will thus conclude; in allowing precedence to action it will thus retain the superiority of the thinking reed. This also is a supremacy not to be disdained.

Pardon these brief reflections and pardon also their brevity, scarcely skimming the question. The process of intellectualism is not the subject I wish to treat: I wish to speak of science, and about it there is no doubt; by definition, so to speak, it will be intellectualistic or it will not be at all. Precisely the question is, whether it will be.

§ 2. *Science, Rule of Action*

For M. LeRoy, science is only a rule of action. We are powerless to know anything and yet we are launched, we must act, and at all

hazards we have established rules. It is the aggregate of these rules that is called science.

It is thus that men, desirous of diversion, have instituted rules of play, like those of tric-trac for instance, which, better than science itself, could rely upon the proof by universal consent. It is thus likewise that, unable to choose, but forced to choose, we toss up a coin, head or tail to win.

The rule of tric-trac is indeed a rule of action like science, but does any one think the comparison just and not see the difference? The rules of the game are arbitrary conventions, and the contrary convention might have been adopted, *which would have been none the less good.* On the contrary, science is a rule of action which is successful, generally at least, and I add, while the contrary rule would not have succeeded.

If I say, to make hydrogen cause an acid to act on zinc, I formulate a rule which succeeds; I could have said, make distilled water act on gold; that also would have been a rule, only it would not have succeeded. If therefore scientific 'recipes' have a value, as rule of action, it is because we know they succeed, generally at least. But to know this is to know something and then why tell us we can know nothing?

Science foresees, and it is because it foresees, that it can be useful and serve as rule of action. I well know that its previsions are often contradicted by the event; that shows that science is imperfect and if I add that it will always remain so, I am certain that this is a prevision which, at least, will never be contradicted. Always the scientist is less often mistaken than a prophet who should predict at random. Besides the progress though slow is continuous, so that scientists, though more and more bold, are less and less misled. This is little, but it is enough.

I well know that M. LeRoy has somewhere said that science was mistaken oftener than one thought, that comets sometimes played tricks on astronomers, that scientists, who apparently are men, did not willingly speak of their failures and that, if they should speak of them, they would have to count more defeats than victories.

That day, M. LeRoy evidently overreached himself. If science did not succeed, it could not serve as rule of action; whence would it get its value? Because it is 'lived,' that is, because we love it and believe in it? The alchemists had recipes for making gold, they loved them and had faith in them, and yet our recipes are the good ones, although our faith be less lively, because they succeed.

There is no escape from this dilemma; either science does not enable us to foresee, and then it is valueless as rule of action; or else it enables us to foresee in a fashion more or less imperfect, and then it is not without value as means of knowledge.

It should not even be said that action is the goal of science; should we condemn studies of the star Sirius, under pretext that we shall probably never exercise any influence on that star? To my eyes, on the contrary, it is the knowledge which is the end, and the action which is the means. If I felicitate myself on the industrial development, it is not alone because it furnishes a facile argument to the advocates of science; it is above all because it gives to the scientist faith in himself and also because it offers an immense field of experience where clash forces too colossal to be interfered with. Without this ballast, who knows whether it would not quit the earth, seduced by the mirage of some scholastic novelty, or whether it would not despair, believing it had fashioned only a dream?

§ 3. *The Crude Fact and the Scientific Fact*

What was most paradoxical in M. LeRoy's thesis was that affirmation that *the scientist creates the fact;* this was at the same time its essential point and it is one of those which have been most discussed.

Perhaps, says he (I well believe that this was a concession), it is not the scientist that creates the fact in the rough; it is at least he who creates the scientific fact.

This distinction between the fact in the rough and the scientific fact does not by itself appear to me illegitimate. But I complain first that the boundary has not been traced either exactly or precisely; and then that the author has seemed to suppose that the crude fact, not being scientific, is outside of science.

Finally, I can not admit that the scientist creates without restraint the scientific fact since it is the crude fact which imposes it upon him.

The examples given by M. LeRoy have greatly astonished me. The first is taken from the notion of atom. The atom chosen as example of fact! I avow that this choice has so disconcerted me that I prefer to say nothing about it. I have evidently misunderstood the author's thought and I could not fruitfully discuss it.

The second case taken as example is that of an eclipse where the crude phenomenon is a play of light and shadow, but where the astronomer can not intervene without introducing two foreign elements, to wit, a clock and Newton's law.

Finally, M. LeRoy cites the rotation of the earth; it has been answered: but this is not a fact, and he has replied: it was one for Galileo, who affirmed it, as for the inquisitor, who denied it. It always remains that this is not a fact in the same sense as those just spoken of and that to give them the same name is to expose one's self to many confusions.

Here then are four degrees:

1°. It grows dark, says the clown.

2°. The eclipse happened at nine o'clock, says the astronomer.

3°. The eclipse happened at the time deducible from the tables constructed according to Newton's law, says he again.

4°. That results from the earth's turning around the sun, says Galileo finally.

Where then is the boundary between the fact in the rough and the scientific fact? To read M. LeRoy one would believe that it is between the first and the second stage, but who does not see that there is a greater distance from the second to the third, and still more from the third to the fourth.

Allow me to cite two examples which perhaps will enlighten us a little.

I observe the deviation of a galvanometer by the aid of a movable mirror which projects a luminous image or spot on a divided scale. The crude fact is this: I see the spot displace itself on the scale, and the scientific fact is this: a current passes in the circuit.

Or again: when I make an experiment I should subject the result to certain corrections, because I know I must have made errors. These errors are of two kinds, some are accidental and these I shall correct by taking the mean; the others are systematic and I shall be able to correct those only by a thorough study of their causes. The first result obtained is then the fact in the rough, while the scientific fact is the final result after the finished corrections.

Reflecting on this latter example, we are led to subdivide our second stage, and in place of saying:

2. The eclipse happened at nine o'clock, we shall say:

2*a*. The eclipse happened when my clock pointed to nine, and

2*b*. My clock being ten minutes slow, the eclipse happened at ten minutes past nine.

And this is not all: the first stage also should be subdivided, and not between these two subdivisions will be the least distance; it is necessary to distinguish between the impression of obscurity felt by one witnessing an eclipse, and the affirmation; it grows dark, which this impression extorts from him. In a sense it is the first which is the only true fact in the rough, and the second is already a sort of scientific fact.

Now then our scale has six stages, and even though there is no reason for halting at this figure, there we shall stop.

What strikes me at the start is this. At the first of our six stages, the fact, still completely in the rough, is, so to speak, individual, it is completely distinct from all other possible facts. From the second stage, already it is no longer the same. The enunciation of the fact would suit an infinity of other facts. So soon as language intervenes, I have at my command only a finite number of terms to express the

shades, in number infinite, that my impressions might cover. When I say: It grows dark, that well expresses the impressions I feel in being present at an eclipse; but even in obscurity a multitude of shades could be imagined, and if, instead of that actually realized, had happened a slightly different shade, yet I should still have enunciated this *other* fact by saying: It grows dark.

Second remark: even at the second stage, the enunciation of a fact can only be *true or false.* This is not so of any proposition; if this proposition is the enunciation of a convention, it can not be said that this enunciation is *true,* in the proper sense of the word, since it could not be true apart from me and is true only because I wish it to be.

When, for instance, I say the unit for length is the meter, this is a decree that I promulgate, it is not something ascertained which forces itself upon me. It is the same, as I think I have elsewhere shown, when it is a question for example of Euclid's postulate.

When I am asked: Is it growing dark? I always know whether I ought to reply yes or no. Although an infinity of possible facts may be susceptible of this same enunciation: it grows dark, I shall always know whether the fact realized belongs or does not belong among those which answer to this enunciation. Facts are classed in categories, and if I am asked whether the fact that I ascertain belongs or does not belong in such a category, I shall not hesitate.

Doubtless this classification is sufficiently arbitrary to leave a large part to man's freedom or caprice. In a word, this classification is a convention. *This convention being given,* if I am asked: Is such a fact true? I shall always know what to answer, and my reply will be imposed upon me by the witness of my senses.

If, therefore, during an eclipse, it is asked: Is it growing dark? All the world will answer yes. Doubtless those speaking a language where bright was called dark, and dark bright, would answer no. But of what importance is that?

In the same way, in mathematics, *when I have laid down the definitions, and the postulates which are conventions,* a theorem henceforth can only be true or false. But to answer the question: Is this theorem true? It is no longer to the witness of my senses that I shall have recourse, but to reasoning.

A statement of fact is always verifiable, and for the verification we have recourse either to the witness of our senses, or to the memory of this witness. This is properly what characterizes a fact. If you put the question to me: Is such a fact true? I shall begin by asking you, if there is occasion, to state precisely the conventions, by asking you, in other words, what language you have spoken; then once settled on this point, I shall interrogate my senses and shall answer yes or no. But it will be my senses that will have made answer, it

will not be *you* when you say to me: I have spoken to you in English or in French.

Is there something to change in all that when we pass to the following stages? When I observe a galvanometer, as I have just said, if I ask an ignorant visitor: Is the current passing? He looks at the wire to try to see something pass; but if I put the same question to my assistant who understands my language, he will know I mean: Does the spot move? and he will look at the scale.

What difference is there then between the statement of a fact in the rough and the statement of a scientific fact? The same difference as between the statement of the same crude fact in French and in German. The scientific statement is the translation of the crude statement into a language which is distinguished above all from the common German or French, because it is spoken by a very much smaller number of people.

Yet let us not go too fast. To measure a current I may use a very great number of types of galvanometers or besides an electrodynamometer. And then when I shall say there is running in this circuit a current of so many amperes, that will mean: if I adapt to this circuit such a galvanometer I shall see the spot come to the division *a*; but that will mean equally: if I adapt to this circuit such an electrodynamometer, I shall see the spot go to the division *b*. And that will mean still many other things, because the current can manifest itself not only by mechanical effects, but by effects chemical, thermal, luminous, etc.

Here then is one same statement which suits a very great number of facts absolutely different. Why? It is because I assume a law according to which, whenever such a mechanical effect shall happen, such a chemical effect will happen also. Previous experiments, very numerous, have never shown this law to fail, and then I have understood that I could express by the same statement two facts so invariably bound one to the other.

When I am asked: Is the current passing? I can understand that that means: Will such a mechanical effect happen? But I can understand also: Will such a chemical effect happen? I shall then verify either the existence of the mechanical effect, or that of the chemical effect; that will be indifferent, since in both cases the answer must be the same.

And if the law should one day be found false? If it was perceived that the concordance of the two effects, mechanical and chemical, is not constant? That day it would be necessary to change the scientific language to free it from a grave ambiguity.

And after that? Is it thought that ordinary language by aid of which are expressed the facts of daily life is exempt from ambiguity?

Shall we thence conclude that the facts of daily life are the work of the grammarians?

You ask me: Is there a current? I try whether the mechanical effect exists, I ascertain it and I answer: Yes, there is a current. You understand at once that that means that the mechanical effect exists, and that the chemical effect, that I have not investigated, exists likewise. Imagine now, supposing an impossibility, the law we believe true not to be, and the chemical effect not to exist. Under this hypothesis there will be two distinct facts, the one directly observed and which is true, the other inferred and which is false. It may strictly be said that we have created the second. So that error is the part of man's personal collaboration in the creation of the scientific fact.

But if we can say that the fact in question is false, is this not just because it is not a free and arbitrary creation of our mind, a disguised convention, in which case it would be neither true nor false. And in fact it was verifiable; I had not made the verification, but I could have made it. If I answered amiss, it was because I chose to reply too quickly, without having asked nature, who alone knew the secret.

When, after an experiment, I correct the accidental and systematic errors to bring out the scientific fact, the case is the same; the scientific fact will never be anything but the crude fact translated into another language. When I shall say: It is such an hour, that will be a short way of saying: There is such a relation between the hour indicated by my clock, and the hour it marked at the moment of the passing of such a star and such another star across the meridian. And this convention of language once adopted, when I shall be asked: Is it such an hour? it will not depend upon me to answer yes or no.

Let us pass to the stage before the last: the eclipse happened at the hour given by the tables deduced from Newton's laws. This is still a convention of language which is perfectly clear for those who know celestial mechanics or simply for those who have the tables calculated by the astronomers. I am asked: Did the eclipse happen at the hour predicted? I look in the nautical almanac, I see that the eclipse was announced for nine o'clock and I understand that the question means: Did the eclipse happen at nine o'clock? There still we have nothing to change in our conclusions. *The scientific fact is only the crude fact translated into a convenient language.*

It is true that at the last stage things change. Does the earth rotate? Is this a verifiable fact? Could Galileo and the Grand Inquisitor, to settle the matter, appeal to the witness of their senses? On the contrary, they were in accord about the appearances, and, whatever had been the accumulated experiences, they would have remained in accord with regard to the appearances without ever agreeing

on their interpretation. It is just on that account that they were obliged to have recourse to procedures of discussion so unscientific.

This is why I think they did not disagree about a *fact:* we have not the right to give the same name to the rotation of the earth, which was the object of their discussion, and to the facts crude or scientific we have hitherto passed in review.

After what precedes, it seems superfluous to investigate whether the fact in the rough is outside of science, because there can neither be science without scientific fact, nor scientific fact without fact in the rough, since the first is only the translation of the second.

And then, has one the right to say that the scientist creates the scientific fact? First of all, he does not create it from nothing, since he makes it with the fact in the rough. Consequently he does not make it freely and *as he chooses.* However able the worker may be, his freedom is always limited by the properties of the raw material on which he works.

After all, what do you mean when you speak of this free creation of the scientific fact and when you take as example the astronomer who intervenes actively in the phenomenon of the eclipse by bringing his clock? Do you mean: The eclipse happened at nine o'clock; but if the astronomer had wished it to happen at ten, that depended only on him, he had only to advance his clock an hour?

But the astronomer, in perpetrating that bad joke, would evidently have been guilty of an equivocation. When he tells me: The eclipse happened at nine, I understand that nine is the hour deduced from the crude indication of the pendulum by the usual series of corrections. If he has given me solely that crude indication, or if he has made corrections contrary to the habitual rules, he has changed the language agreed upon without forewarning me. If, on the contrary, he took care to forewarn me, I have nothing to complain of, but then it is always the same fact expressed in another language.

In sum, *all the scientist creates in a fact is the language in which he enunciates it.* If he predicts a fact, he will employ this language, and for all those who can speak and understand it, his prediction is free from ambiguity. Moreover, this prediction once made, it evidently does not depend upon him whether it is fulfilled or not.

What then remains of M. LeRoy's thesis? This remains: the scientist intervenes actively in choosing the facts worth observing. An isolated fact has by itself no interest; it becomes interesting if one has reason to think that it may aid in the prediction of other facts; or better, if, having been predicted, its verification is the confirmation of a law. Who shall choose the facts which, corresponding to these conditions, are worthy the freedom of the city in science? This is the free activity of the scientist.

And that is not all. I have said that the scientific fact is the translation of a crude fact into a certain language; I should add that every scientific fact is formed of many crude facts. This is sufficiently shown by the examples cited above. For instance, for the hour of the eclipse my clock marked the hour α at the instant of the eclipse; it marked the hour β at the moment of the last transit of the meridian of a certain star that we take as origin of right ascensions; it marked the hour γ at the moment of the preceding transit of this same star. There are three distinct facts (still it will be noticed that each of them results itself from two simultaneous facts in the rough; but let us pass this over). In place of that I say: The eclipse happened at the hour 24 $(\alpha-\beta)/(\beta-\gamma)$, and the three facts are combined in a single scientific fact. I have concluded that the three readings α, β, γ made on my clock at three different moments lacked interest and that the only thing interesting was the combination $(\alpha-\beta)/(\beta-\gamma)$ of the three. In this conclusion is found the free activity of my mind.

But I have thus used up my power; I can not make this combination $(\alpha-\beta)/(\beta-\gamma)$ have such a value and not such another, since I can not influence either the value of α, or that of β, or that of γ, which are imposed upon me as crude facts.

In sum, facts are facts, and *if it happens that they satisfy a prediction, this is not an effect of our free activity.* There is no precise frontier between the fact in the rough and the scientific fact; it can only be said that such an enunciation of fact is *more crude* or, on the contrary, *more scientific* than such another.

(To be continued)

IS THE MIND IN THE BODY?

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A NUMBER of years ago the eminent anatomist, Dr. Joseph Leidy, told me that a modern Maecenas had offered to pay for the finest microscopes if he would undertake a search in brains for ideas.

The professor, who never pretended to be either a psychologist or a philosopher, rejected the proposal on the ground that the investigation must be a profitless one. His common sense and common experience of mind and body led him to believe that mental phenomena are not things to be captured as the result of such a method of attack.

But what induced him to take this stand? Common sense and common experience, in some sense of the terms, men have always had —at any rate, they have had what may be called by these names from a very early period. And yet there was a time, and a very long time, during which such an investigation would not have impressed men of acuteness and learning as necessarily an absurd one.

There was a time during which, that is to say, men regarded minds as something frankly and unequivocally material. Something elusive, if you please; something too fine and subtle to be directly apparent to the senses; but, nevertheless, something just as material as wood or stone or flesh or bone, and just as really in this or that portion of space.

Almost at the dawn of reflective thought we find men identifying the mind with the breath which we inhale and exhale; and when, later, the time was ripe for the birth of an atomic theory, a crude and hasty one, it is true, but the forerunner of the one which was to appear later, we find them describing it as composed of atoms, which enter and leave the body as do other kinds of matter.

About four hundred years before Christ, Democritus, who was a man of scientific temper, even if of unavoidably limited scientific attainment, placed before the world his atomistic doctrine. A hundred years later that easy-going philosopher, Epicurus, adopted his theory, and founded a long-lived school. In the first century, B. C., the Roman poet, Lucretius, wrote his magnificent poem 'On Nature,' and set forth in noble verse the Epicurean doctrine touching the universe of things physical and mental.

The nature of the mind and soul, says Lucretius, is bodily; for when it is seen to push the limbs, rouse the body from sleep, and alter the countenance

and guide and turn about the whole man, and when we see that none of these effects can take place without touch nor touch without body, must we not admit that the mind and soul are of a bodily nature?

But of what sort of bodies must we conceive this part of a man to be composed? The mind acts with great nimbleness; it is very easily moved, so it is inferred that it consists of bodies very small, smooth and round:

The following fact, too, demonstrates how fine the texture is of which its nature is composed, and how small the room is in which it can be contained, could it only be collected into one mass: soon as the untroubled sleep of death has gotten hold of a man and the nature of the mind and soul has withdrawn, you can perceive then no diminution of the entire body either in appearance or weight; death makes all good save the vital sense and heat. Therefore the whole soul must consist of very small seeds and be inwoven through veins and flesh and sinews; inasmuch as, after it has all withdrawn from the whole body, the exterior contour of the limbs preserves itself entire and not a tittle of the weight is lost.[1]

Lucretius thinks that something analogous takes place 'when the flavor of a wine is gone, or when the delicious aroma of a perfume has been dispersed into the air.' Something is gone, but the weight of objects is not altered by the loss.

For hundreds of years it did not seem to men ridiculous to talk about the mind in this way. Yet they all had the common experiences of mental phenomena that we have. Nor was it the weakness of a single school to be thus grossly materialistic. The Stoic school, the great rival of the Epicurean, and also a long-lived one, was in its way as materialistic. The Stoics identified the soul of man with the warm breath that is found in his body.

Indeed, it is not too much to say that, among that very acute people, the Greeks, from whom we have gained so much, it did not seem at all unnatural to conceive of the mind of man as a breath, or a fire, or collection of fine small material particles. Some raised their voices in protest, but the protest was scarcely effectual.

Now, suppose someone had come to Lucretius and had initiated him into the mysteries of the microscope. Would he have scouted the idea of getting a direct vision of the 'seeds' that constituted the mind of man? I think not; there was certainly nothing in his doctrine to make the idea absurd to him. If, in general, invisible material things can be made visible, and the barrier set by their minuteness can be done away, why should not coughed-out soul atoms be captured and inspected?

But Professor Leidy was amused at the notion of the investigation proposed to him. Why was this? His experience of the mind was no more direct or complete than that of Lucretius. He had never

[1] 'De Rerum Natura,' III., trans. Munro.

given half as much thought to the nature of minds, for he was little interested in psychology. Nevertheless, his common sense—whatever that may be—led him to laugh at a way of looking at things that could not have struck Lucretius and many other able men as absurd at all.

It is extremely interesting to ask why the men of our day, I do not mean the professional psychologists, but the great mass of intelligent persons who do not care much for psychology, and who know little of philosophy, should take up certain ways of regarding things mental, and should unhesitatingly repudiate others which have once been popular. We can not in the least explain it by saying that their own experience of minds leads them to embrace such conclusions. As a rule, they do not reflect upon their experiences of their minds at all, and some of them are hardly capable of serious reflection upon the subject. As early as the seventeenth century, John Locke remarked that "the understanding, like the eye, whilst it makes us see and perceive all other things, takes no notice of itself; and it requires art and pains to set it at a distance, and make it its own object." To this modern psychologists will heartily subscribe.

The fact is that the average man's notions about the mind are a part of his share in the heritage of the race. He who knows something of the history of human thought finds in them the echoes of old philosophies—traces of theories sometimes the most fantastic. The common sense which guides men is the resultant attitude due to many influences, some of them dating very far back indeed.

I have said that, even among the ancient Greeks, there were protests against the materialization of the mind. Both Plato and Aristotle stood out against it, each in his own way. It is true that Plato distributes the soul through the body in a way that might strike an Epicurean as not unnatural—a part of it was below the diaphragm, a part of it in the chest, and a part of it in the head. But he does speak of this last and noblest part in somewhat the same tone as that in which men came later to speak of the human mind. Aristotle follows his teacher in regarding the reason, at least, as something to be carefully distinguished from everything material. However, it is interesting to note that he conceives of the divine reason, or first cause of motion, as *touching* the world *without being touched by it.*

May we not describe this last notion as material at one end, so to speak? If reason is so immaterial that it can not be touched by matter, what does it mean to say that it touches matter? But we must get used to queer ways of talking about minds, if we will follow the history of human thought. The seed dropped by Plato and Aristotle has grown into a tree when we come to Plotinus the Neo-Platonist, who lived in the third century after Christ.

Plotinus was a man of mystical tendencies, but he was both learned and acute. He insists that the soul is an immaterial substance, and he tries to give us a notion of the way in which such a thing can be related to the body. To put it into the body, as Epicurus or Lucretius did, would be to deny its immateriality. This he can not do. To deny that it is related to the body at all is too much even for a philosopher.

In his perplexity he follows a middle course. He tells us that the soul is not in space and is not in things, in the strict sense. But in a certain sense it is in things, or is present to things. It is as a whole in the whole body, and is at the same time wholly in every part of the body; and is, thus, at once divisible and indivisible.

One may legitimately object to this curious doctrine, and criticize Plotinus as giving with one hand what he takes away with the other. It is easy to see what he tried to do, and what he actually did do. He tried to draw a clear distinction between mental phenomena and physical, and to tell us how they are related. He succeeded only in making of the soul an inconsistently material thing, existing in space in an inconceivable way.

But it will not do to treat Plotinus with contempt, and to pass over his doctrine as insignificant. He made an earnest attempt to draw a line between the mental and the physical—surely some such line ought to be drawn—and his influence upon men's minds has been enormous. His doctrine was taken up by Augustine, from whom it passed to the philosophers of the middle ages; and it came ultimately, after undergoing various modifications, to the modern philosophers. Distinct traces of it are to be found in some of the psychologies written at the present day and used in our colleges.

In the seventeenth century that remarkable man Descartes arrived at a fairly clear comprehension of the mechanism of the human body, and of the significance in it of the brain and the nerves. He concluded that the soul or mind has its 'chief seat' in the pineal gland in the brain, and that messages are carried to it from the various parts of the body. Yet he never ventured to put the soul quite frankly and unequivocally in the pineal gland. He still held that the soul was united to all the parts of the body 'conjointly'—the old Plotinic notion.

In other words, he did not go back to Lucretius, and he did not go forward to a clear distinction between mind and body. He remained halting in indecision; he left a dark place for his successors to illuminate with such light as they could furnish. They have been at the work ever since, and have had varying degrees of success.

Now the speculations of the philosophers, especially when they touch upon those things which are supposed to be of great moment to

mankind, do not remain the property of the philosophers. They ooze out into general literature and become, so to speak, the common property of mankind. In the present instance, we find in the attitude of the majority of the cultivated persons who surround us to-day unmistakable traces both of the crude materialism which seems so natural to man when he first begins to think about the mind, and of the line of speculation indicated above. Men think of the mind as *somehow in the body,* in the brain; and yet they are not willing to admit that it is *unequivocally* in the body—in it as brain cells are, as blood corpuscles are, as are any of the material constituents of the body itself.

Ask the average undergraduate student—who can not be accused of having done much thinking for himself, but who holds the vague opinions that he has absorbed from those about him—ask him where his mind is, and he will probably answer that it is in his brain. Ask him, further, whether there is any hope of getting at it as one may hope to get at the material constituents of the brain, and I think he will say, No! It is *there,* and yet *not exactly there;* it is there in a Pickwickian sense. He feels as Dr. Leidy did, and his feeling has exactly the same foundation. It rests upon an ancient tradition.

What, then, is the relation of mind and brain? We seem to be left with an 'in' on our hands that is not really an *in* at all, but is something else. What is it? Our student can not tell us, nor can those from whom he has picked up his vague and inconsistent notions.

To those who wish to think clearly all this is naturally unsatisfactory. Those who busy themselves with the problem are impelled to try to make the matter less vague. Now and then, even in our time, men go back, to accomplish this end, to something very like the ancient materialism which the world outgrew so long ago.

Thus we now and then hear it maintained that thought is a *secretion* of the brain. Half a century ago much was said about this, and to many the doctrine seemed plausible. It certainly does appear to make clearer the relation of mind and body, if we hold that mental phenomena are related to the brain as the saliva is related to the salivary gland. If we can say this, we may maintain that the mind is *in* the body in a literal and unambiguous sense of the word.

But may we legitimately speak thus? The secretion of a gland is a something so unequivocally material that it can be treated just like other material things. It can be collected into a test-tube and analyzed by the chemist. Has any one ever succeeded in filling a test-tube with mental phenomena? in bottling and analyzing in a laboratory pains and pleasures, memories and anticipations? Dr. Leidy, who knew a vast amount about the secretions of glands, did not confound ideas with secretions, and would not even attempt to treat them in the same way.

It is, indeed, too late in the world's history to try to revive the crude materialism of the past. Whatever else the philosophers have done, they have fixed our attention upon the striking distinction between mental phenomena and physical. He who has once grasped this may be a semi-materialist—an unconscious materialist—as is the plain man to-day, notwithstanding his assertion that the mind is immaterial; and as is his more learned neighbor the 'interactionist' psychologist, of whom I spoke in a recent paper in this journal.[2] But he can scarcely be a materialist out-and-out.

Hence, men have felt impelled to turn to other ways of making clear the relation of mind and body. Some have said that consciousness is a *function* of the brain; some, that it is the *inside* of that which, regarded from the *outside,* is brain-change; some, that it is the *reality* to which physical phenomena may be referred as *appearance.*

It is not well to let any one of these statements pass without scrutiny. What do we mean when we say that the mind is a function of the brain? Do we mean only that, given certain changes in the brain, certain mental phenomena come into being? It still remains to ask *how* the mental phenomena are related to the brain. Are they *in there?* and if not, where are they? or are they anywhere, in any intelligible sense of the word? The word 'function' is not a word to conjure with. We may call motion a function of brain molecules, if we choose; but evidently a memory or a feeling of pain is not a function of this kind, and the question still confronts us: What kind of a function is it?

As to the statement that mental phenomena may be regarded as the inside of that which, looked at from the outside, is brain-change—this we may take as merely 'a manner of speech,' as a something to say to troublesome persons who ask us difficult questions and must be answered at all hazards. When we say that seeds are inside of an orange, we know what we mean. They are things that occupy space, and can be found in the spaces that they occupy. A leather purse may be lined with silk, and it may contain silver; but try to line a leather purse with painful emotions, and to fill it with hopes and expectations! We play with the words 'inside' and 'outside' when we talk in this way, and it is not proper to play when one is philosophizing, some learned men to the contrary notwithstanding.

Nor should the words 'appearance' and 'reality' be abused recklessly. They have a proper meaning, and we ought to keep to it. We say that a tree seen at a distance *looks* small, but *really is* large; and we say that a stick stuck into water *looks* crooked, but *really is* straight. Certain experiences we look upon as appearances, and certain others, which for some reason we regard as more satisfactory or more normal,

[2] POPULAR SCIENCE MONTHLY, February, 1907.

we speak of as realities. Both appearance and reality are given in sensation, and we observe a connection between them. They belong to the same order of experiences.

Thus, I may sit in the highest gallery of the opera house, and may say: What *looks like* a row of small shiny discs in the parquet *is really* a row of bald heads. Be it remarked that the reality in this case is a something that can unequivocally be located; it is in the parquet, and it occupies space. It can be seen close at hand, and it can be touched with the fingers. May I say that what *seems to be* a brain-change in one of these heads *really is* a sensation of sound? Is the sensation of sound *there?* does it occupy space? is it literally in the head?

Evidently we are here again concerned only with 'a manner of speech'—with a loose expression which cloaks one's ignorance, and which borrows what force it has from a false analogy. If we say that the sensation of sound is the 'reality' and the brain-change the 'appearance,' we abuse two respectable words, in common use, that have a right to better treatment.

The truth is that it is better to recognize that mental phenomena must not be conceived after the analogy of material things at all. We may, of course, go on talking about mind and body as other people do. In common life a pedantic exactitude of expression is out of place. But when we try to be scientific we must strip off crude inherited materialisms, the echoes of a remote past.

The man who has done this the most completely is the parallelist. The limits of this paper prevent me from setting forth his doctrine, but I have elsewhere[3] tried to show simply and clearly just how much he has a right to mean by it. He denies frankly that the mind is in the body, as also that one has the right to hint, by the use of vague and ambiguous material analogies, that it is *somehow* in the body. It was a philosopher of the seventeenth century who first thought out the doctrine, but it was a scientist of the nineteenth century, Professor W. K. Clifford, who made it popular to us moderns. To him much of the credit for the present revival of the doctrine must be accorded.

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[3] 'An Introduction to Philosophy,' N. Y., 1906, chapter IX.

DRUG ABUSES, THEIR EFFECTS ON THE PEOPLE

By J. MADISON TAYLOR, A.B., M.D.
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DRUG abuses have become so grave that at last the medical profession is compelled to correct them. The public should learn clearly our mutual positions in the proper and improper use of drugs, which are chemical substances found useful or necessary to combat the effects of disease. They are demanded in many instances where no other known means are available. It is obvious, however, that misuse is capable of vastly greater harm than their absence.

Certain 'schools of medicine' are recognized, differing chiefly in the opinions entertained as to what drugs shall be employed and what effects are to be expected from them, as well as the manner of their administration. The 'schools' most prominent are two; the regular profession of medicine and that of homeopathy. Though starting from the same basis, *i. e.*, long experience in the selection and preparation of remedial substances, begun in the earliest periods of history, a time came when revolt arose from the existing confusion. Hahneman, a vigorous dogmatic thinker, determined to change the point of view hitherto entertained, and in the process accomplished a number of important results. The chief of these was in the preparation of drugs, and in the amounts administered. He evolved a number of opinions and many shrewd conjectures, some fanciful and some based on careful observation, as to drug effects, direct and indirect. To-day, after a century of critical scrutinization of recorded principles, these two schools differ on essential points inconsiderably.

The vital point is that drugs in one form or another are popularly believed to be endowed with enormous powers for good. History encourages this belief, especially when one considers the discovery of cinchona and certain specifics, such as mercury, and later the antitoxins. The utility of drugs, remedial substances foreign to the economy, is of the highest order in many forms of disease. In the future when the principles of their action are fully understood, both from experience and physiology, they will continue to exert even more definite usefulness. Some hygienic and other measures are capable of replacing them, many of supplementing them, but in certain grave emergencies they are absolutely required. To omit their use, and expect to discharge full duty to the sick, is a failure to furnish something essential, permitting a person endangered by the tyranny of

disease to suffer neglect. It is conceivable that in the future an adequate growth in knowledge of the inherent resources of the organism may lead to their omission; but that day is not yet come.

Wherever there is demand it is met by supply. An overmastering desire of most people is to secure the largest material benefits for the least money. Where a physician is consulted and medicines are ordered, these must be paid for in addition to the fee for advice, hence all manner of devices are employed to reduce the cost. The fact is too often overlooked that only by the direct application of skilled advice to the instance, then a suitable remedy being chosen, is safety to be secured. The business man might otherwise as well depend on law primers and omit to consult skilled attorneys. The unwarrantable repetition of prescriptions emanating from physicians of admitted wisdom, and the recommending of these to friends and neighbors gratuitously, are obvious abuses of what is essentially an economically scientific procedure.

As commercial enterprises grew in complexity and breadth of scope, these 'favorite prescriptions' began to be manufactured, advertised and distributed in wholesale fashion. People were encouraged to believe that they might thus secure medical combinations of great power at first hand, and the apparent but false economy was broadly welcomed. These preparations were made agreeable, or at least acceptable, and any one could secure a bottle full of promising potentialities guaranteed to overcome whatsoever ills might occur, real or fancied. Hence arose two classes of drug combination, the nostrum, offered directly to the consumer, based on the commercial principle of exploiting 'favorite prescriptions,' and the proprietary preparations offered to the physician, purporting to be improvements, the product of laboratory researches, constituting true chemical discoveries or refinements and specializations in scientific manufacture. As to the former (the nostrum), it is impossible to see, viewed with the utmost charity, any reason for its existence. Of many of the proprietary preparations, it must be admitted that they evidence excellent advances made by the reputable drug manufacturers, who devote much money and scientific effort to the perfection of methods and products. They have, in many instances, however, transgressed their just prerogatives and invaded the territory of the physician. They make diagnoses, teach us pathology and instruct us how to prescribe.

The sales of nostrums have grown so large as to constitute an overwhelming proportion of all medicines consumed. Their unguided use induces drug habits, fetish worship, incalculable harm.

The educated experienced practitioner of medicine has been forced by the reckless drug consumption thus induced to take not only a secondary position, but is placed low in the scale of guiding influence,

in legitimate rewards. The sphere of the physician is of largest practical utility to the community. He it is who, by long years of close study, hospital teaching and personal experience, becomes gradually equipped to fill the responsible post of conservator of public and private health, of guide to the delicate human mechanism when disordered. His problem is a complex one for which he must furnish the highest qualities of character, wisdom, tact, sympathy and personal kindliness. He is the one who, even in those situations of gravity when the onslaughts of disease can not be stayed, comes closer to the heart, the soul and person than even the man of God. He should be (and in this as in other ways he seldom fails) in all respects a man, typifying the most estimable advisory qualities of friend, father, brother. No household is safe without a wise family physician in whom the members can repose confidence. He can, and does, furnish far more than medical advice; he is the counselor in a thousand directions, whether in illness, sorrow, domestic catastrophe, mental shock, perils of countless sorts and degrees. He can only display his resourcefulness, his manifold capacities, if he be permitted free access to the household to enable him to foresee, warn and thus prevent those calamities which too often can not be cured. It is an inconsiderable part of his duties to administer drugs, though these are among his keenest weapons. He should possess the fullest knowledge of their uses and employ them with skill and timeliness.

How far could a crew of bankers, of clergymen, of merchants guide and use a man-of-war? What sort of pictures could a man untrained in pictorial art paint, were he provided with the full accoutrements of a skilled artist? How long would a child alone continue to live in a butcher shop stocked full for Christmas feasting? These analogues are mild compared with that of an ailing man or woman turned loose in a chemist's shop to select remedies unaided. Yet many people take advice and swallow drugs, deadly in ultimate intent, incited thereto by each other, by the newspapers, by alluring labels on the bottles, and still regard themselves as shrewd. They often do worse, if, failing good effects from these nostrums (and provided they survive) turning to charlatans, who trade upon human credulity, themselves not realizing that sick bodies always enshrine disordered minds.

The sphere of the physician is not that of a merchant selling wares; he is the scientific and practical guide in times of physical danger. His duties and responsibilities are theoretically, but not practically, understood. The public expects of him who guides the helm in times of disease and threatened death ethical qualities which he seldom fails to furnish. If in his best judgment drugs are needed, he it is who should select and change. He may be less wise than he might, or even than he is estimated, but assuredly he is vastly better fitted at all

times to direct and control the course of physical derangements than even the wisest layman.

Commercial principles are comprehensible by all; financial success is obtrusively tangible. A firm earning enormous sums by the sale of remedies is naturally supposed to be offering a valuable product. The professional spirit, the ethical, the scientific principles on which action must be based to be intelligently successful, are thus obscured. The great proportion of people of this country estimate the scientific practitioners of medicine, equipped as they are with years of patient scientific self-sacrificing education, as of small account compared with the material achievements of the great factors of nostrums and proprietary medicines. The sphere of acquired wealth, in comparison with this quiet faithful service, is obvious, speaks a comprehensible language.

The members of our profession in the concrete have quietly submitted to a domination at the hands of these manufacturers which is no less than contemptible. In matters of politics 'money talks.' The great power of the country resides in the public press. With them money also talks. Advertisements are paid for which alone aggregate sums close to the total of the gross earnings of legitimate practitioners. Hence naturally are induced alliances, defensive and offensive, whereby the power of the great drug houses becomes increasingly intrenched for good or evil.

The members of a learned profession are thus made to appear of little account. When they protest, as individuals, their voice is overborne by platoon fires of pseudo-scientific, advertising jargon till most of us become dazed and all but ready to capitulate before we can place our evidence on record, or even get a hearing.

Incredible sums of money are spent by the great drug manufacturing houses to make and hold their power. They are almost impregnable, but not quite. No physician in America earns such an income as is enjoyed by many individual members of these firms who live like royal princes, leaving at death fortunes which, when subdivided, suffice for generations of affluence. Yet the cure of all this peril is simple, but by no means easy of attainment. Physicians should act in concert and consistently. They should acquaint themselves accurately with the facts and educate the public to know where and how drugs may be best used, and especially point out where they should not.

First let us, every one, learn and make clear to the public at all times what are the effects of nostrums. Can they exercise any beneficent purpose? Emphatically no. What good end can they serve? It is difficult to see one. What possible advantage can accrue from this obtrusion of drugs in attractive shapes upon the receptive consciousness of the community? It may be claimed that every man has

the right to make free choice of the treatment for his bodily ailments. Yet the practise of self-medication is one of the most deplorable relics of the dark ages when the treatment of bodily ailments was confused with matters of conscience.

Consider for a moment the gravity of a peril for which it is difficult to see a remedy. These aggregations of capital *must sell* to maintain themselves. If the market is oversupplied they *must make another market.* If physicians do not wish to use such preparations as they furnish, they must be induced to do so, *their hands must be forced.* If the manufacturer sells directly to the public, *via* the druggist, every device must be employed to increase retailing to the consumer. If a man has no ailment *he must be taught to think he has one.* If he has recovered from an ailment he must forsooth thereupon be made fat or thin. Women are educated to believe they require a host of remedial articles, in reality quite supererogatory. Babies who would thrive best by instinctive maternal teachings are made to appear in need of special foods, soothing agents, etc. In short, healthy folk are taught to become hypochondriacs. All this merely to furnish a brisk market when selling has grown languid.

One closing thought we commend to all, especially to clergymen and religious folk. Can anything be more venal, more opposed to the fundamental principles of ethics, more an earning of money by encouraging misconceptions of our physical and mental feebleness, than many of the ordinary advertisements in the public press of remedies, of drugs, or other semi-medical materials, waters, instruments, etc.? If these bold emphatic advertising statements contain some elements of truth they are too often grossly overstated. The sale of 'get well quick' remedies for venereal diseases causes a confidence unwarranted. Thus thousands of innocent women are infected, rendered invalids for life.

There is only one safe rule when in trouble. Seek expert, honest, reputable counsel and be guided by it. *This is of paramount importance when the body is disordered because then also is the mind, the judgment, likewise impaired.*

ILLUSIONS OF VISION AND THE CANALS OF MARS

By Professor ANDREW ELLICOTT DOUGLASS
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THAT fascinating mystery, the planet Mars, will again approach the earth this summer. Again the nightly watcher will note the diminishing snow caps at the poles, the dark areas of vegetation, enlarging with the welcome moisture, and, perchance a cloud or two that, lingering over the cold Martian night, is dissipated in the sunrise heat, revealing thus its character.

Again also will hundreds of fine dark lines appear, which from their straightness and artificial appearance, seem to attest the existence of highly intelligent beings upon our neighbor.

It is right and natural that we should first regard these faintest of markings as realities upon the planet. The writer can certify to their apparent genuineness, for he has pictured numbers of them in half a dozen favorable oppositions since 1892. To him they were real until time proved that in the faintest markings astronomers failed of satisfactory agreement. In the larger markings, and even in the larger canals, conflicts of evidence do occur, but are never troublesome. One may confidently say that such realities do exist. But with the very faint canals whose numbers reach occasionally well into the hundreds, discordance reigns supreme, and it is frequently found that different drawings by the same artist antagonize each other across the page.

Considerations along these lines led the writer to study seriously the origin of these inconsistent faint canals by the methods of experimental psychology, and the application of those methods has resulted in a new optical illusion and new adaptations of old and well-known phenomena, all of which apply profoundly to the case in hand. Their description and application follow.

Halo

The most important of these phenomena is the halo.

To observe this, place Fig. 1 at a distance of six to eight feet from the eye and look at it from time to time, taking care to avoid fatigue. Around it will appear a whitish area limited externally by a faint dark line forming a perfect circle, as if traced by a pair of compasses. This external ring or secondary image has a sensible width and appears blackest on its sharp inner edge. When once caught, which is usually

at the first view, it is a striking phenomenon. I find on the whole that trained eyes are the ones which see it most quickly.

A more beautiful and elegant way of making the experiment is by standing a black-headed hat pin in the middle of a white-walled room, and looking at it against the distant white background. Around the head of the pin will then appear this halo, more beautiful than before, suspended in mid-air, in the good old-fashioned manner of saintly halos.

The experiment described above gives the 'negative' halo. It will be generally referred to in this article, because it is more easily seen than the 'positive.' The 'positive' form of the halo, however, is most readily seen by a similar method. Let a white-headed pin be substituted for the other, and looked at against a black background. Similarly, a white circle is seen. The difficulties in this case arise from the reflections on the head of the pin and its generally less even illumination.

FIG. 1. THIS SPOT SHOULD BE VIEWED FROM A DISTANCE OF SIX OR EIGHT FEET, with care to avoid fatigue or after-images, in order to see the fine dark halo ring about it at the distance indicated by the smaller dot.

The effect, however, is the same. Extending all round the head of the pin at a distance of about 7′ of arc (one inch at a distance of 500 inches) is an intensified zone in which the color of the background appears stronger; and outside of that a reduction zone, or ring, or secondary image, in which the intensity of the background is reduced by the addition of some of the color of the spot observed.

In order to find the cause of this halo, many tests were made, of which the first was upon the size of the central spot. It was found that the distance from the edge of the spot to the secondary image is constant; that the width of the secondary image increases to some extent with the size of the spot, and that the intensified area increases its intensification with the size of the spot. If the spot is so small as to be barely visible, the halo may still be seen, but the intensified zone then appears of the same intensity as the background.

If the spot is enlarged sufficiently, both positive and negative halos are seen along its margin, one outside and one inside, so that in a straight line separating light and dark areas, the positive halo may be seen in the dark area, and the negative halo in the light. If two small spots are placed so that their halos intersect, the halo of each

may usually be seen complete. If the spots are larger, the halos can not be traced within each other's precincts, and on enlarging the spots still more, they soon act as one mark with regard to the halo, which assumes an elliptical form around them. From these and other experiments along the same line, it appears that the intensified zone or white area, as I shall generally call it, referring to the negative experiment, displays an increased sensitiveness to presence or absence of color of the spot looked at, but a decided deadening in the perception of details.

My first idea in regard to this halo was that it came to life like the camera ghost, from reflections between lens surfaces in the eye, but I found that it could be produced through any portion of the crystalline lens. A pin hole 1/50 inch in diameter passed before the pupil of the eye demonstrated this.

It then seemed possible that some form of halation in the membranes close to the retina might produce this effect. The common photographic halation ring, which closely resembles it, is produced by reflection from the back of a glass plate but can only occur under certain conditions. This halo, however, occurs on all margins and can not be due to that cause.

FIG. 2. PHOTOGRAPHIC HALATION RING ABOUT CANDLE FLAME, formed by reflection inside the glass plate on which the picture was taken, very similar in its appearance to the halo here described.

At this stage, a certain 'chromatic ring,' described below under that heading, was observed, and suggested some obscure color conditions as the cause. Hence, color tests were made in large numbers, and the black spot was tried on different colored backgrounds without effect. Different colored spots against a dark background were also observed without effect, save that the secondary image when sufficiently bright was seen to be of the color of the spot itself; therefore color was not responsible for the halo.

But these color observations opened up a very interesting line of study. The color tests had to be made in the positive form with all the attendant difficulties of fatigue and after-images. It was found that a short gaze at a red disk on a black background, followed by a slight movement of the eye to one side, carried away a dark green after-image of the disk surrounded by a red margin, about the size of the intensified zone. This intensified zone became still more con-

spicuous by longer fixation of the gaze upon the colored spot. To observe this, half-inch disks of red, yellow, green and blue paper were pasted vertically on ends of long needles and placed in strong lamplight at a distance of eight feet from the eye. After long unwinking gaze at one of these disks, until general color sensitiveness seemed to be disappearing and the color of the disk itself seemed to be spreading out around it, a quick closing of the eye, or the mere placing of a sheet of paper close before the open eyes, revealed a very interesting succession of changes, as follows:

1. A black or dark green disk with a limited red margin filling the intensified zone, limited by the dark halo. This effect lasted for a very brief instant of time, like the common positive after-image.

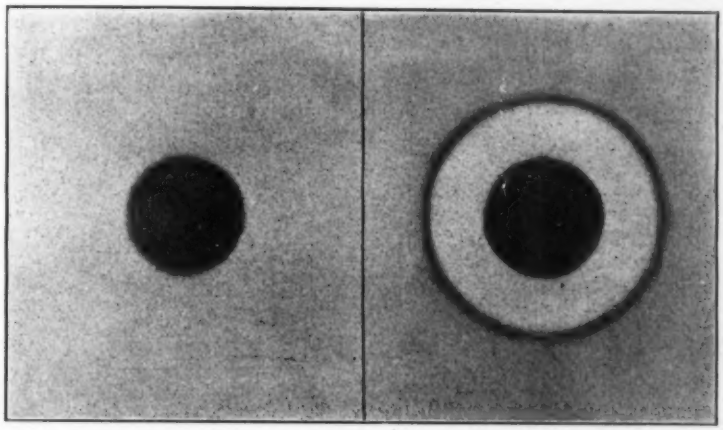

FIG. 3. 'DOT' MOTE OUTSIDE THE YELLOW SPOT.

FIG. 4. 'DOT' MOTE IN YELLOW SPOT BUT NOT IN FOVEA.

2. The outline soon reappeared; the red disk and all white objects taking a dark indigo-blue color, the remainder of the field being a bright yellow. This effect might last a minute or two.

3. During the height of this effect a negative halo appeared for a time around the dark after-image of the disk at the usual distance of 7′. The success of this experiment depends largely upon steadiness of vision and avoidance of winking. The determination of the effect of different colors and conditions offers a fine field for investigation.

The next test with a view to locating the cause of this halo phenomenon was made on motes that so often float by the line of vision. This was done by looking at a highly-illuminated area through a small pin hole held close to the eye. Three classes of motes were observed: First, the usual cell fragments and groups; second, rapidly moving objects probably of similar character, and, thirdly, minute black dots which from their motions seemed to be located in the same region as

the first, probably not far in front of the retina. On this last class, some beautiful halo phenomena were observed.

When one of these spots was outside a region identified as approximately the yellow spot, it appeared as a circular dark area of some 30′ diameter as shown in Fig. 3. When it came within the yellow spot, it became lighter, and was surrounded by the halo, with its intensified zone and secondary image well defined as in Fig. 4. When, however, it came within the region of most distinct vision, which was very rare, it gave the most beautiful halo effect I have yet seen. It had a dense, black spot in its very center, usually well rayed; then, a light zone limited by an intense black ring, which in turn produced its own complete halo. This form is shown in Fig. 5.

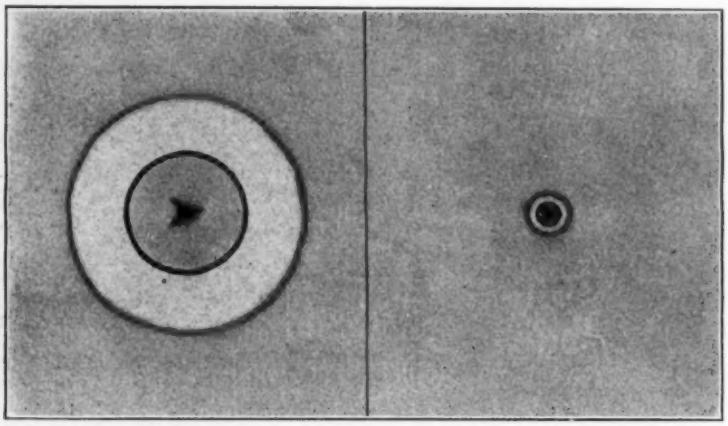

FIG. 5. 'DOT' MOTE IN FOVEA.

FIG. 6. SAME AS FIGURES 5, VIEWED AT CLOSE RANGE. Notice different length of rays compared to diameter of ring.

This mote observation is by no means easy. I have often waited fifteen minutes for a mote of this type to appear, and only once have I kept one in sight for any length of time. It then remained in the center of vision for at least twenty minutes. Usually, they float past the center of the vision and give one only a brief view. The size of pin hole used is 1/50 inch. With a much larger hole, say 1/20 inch, they become blurred. By getting near a large lamp shade so that a wide angle of light is viewed, they are best discovered. Then one may retreat from the light and view them as illustrated in Figs. 3, 4 and 5.

The rays observed in the central spot are very interesting. Their length offers a means of measuring the height of the spot above the retina. A short calculation upon approximate data results in 0.002 inch as the distance of the spot from the retina.

It is true that these mote observations require great patience, but

the beauty of the phenomena repays the effort. There is a sharpness and a density about the inner halo around the spot itself which does not characterize the ordinary outer halo. For such differences I have no explanation to offer.

Not only is the cause of these details very difficult of detection, but the origin of the whole halo phenomenon is equally so. It probably lies in the obscure reactions that change light waves into nerve impulses. One thing which the intensified zone does do is to help correct for rays which the irregular refraction of the eye scatters across a margin; and so this light area fulfils some psychological necessity.

The fact that in the first flash of after-images this zone becomes occupied by the color of the object looked at (like the common positive after-image) suggests that it is a zone in a condition of expectant attention with reference to that color. If, for example, a red disk is observed, the nerves that perceive that color are in full activity, where the stimulus of the image falls on the retina. For a certain distance away from the active retina, they are aroused into a condition of readiness for activity or expectant attention. The secondary image acts like the fatigue area, for it reverses in the after-image.

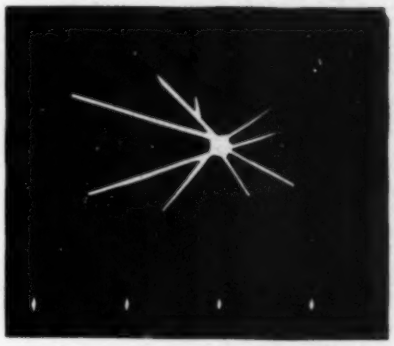

FIG. 7. STELLAR RAYS.

The significance and application of the phenomena are easier. From the psychological standpoint, its immediate application is to questions of contrast. Contrasts are divided into two classes: First, successive contrast, due to fatigue and rest; second, simultaneous or marginal contrast, now seen to be a subordinate part of this halo phenomena. Marginal contrast has been long known, and its after-image, the 'Lichthof' of Hering, has been described. The fact that the halo phenomenon definitely limits the region of marginal contrast and displays a secondary image in a definite position proves it to be the more fundamental phenomenon. We have here, therefore, a new illusion of interest to psychologists and of great significance in its application to astronomical work.

RAYS

Unlike the halo, the ray phenomena are familiar and involve no new principle, but the idea of rays around a black spot is new to me, and quite as important as the halo in its application to visual work by telescope or microscope. As all know, the rays on a star are pro-

duced by irregular refraction in the eye, originating in what are known as the stellate figures. The figures seem to be construction lines, as it were, in the crystalline lens, and develop during its growth. They are permanent in form, when adult years are reached, and may be

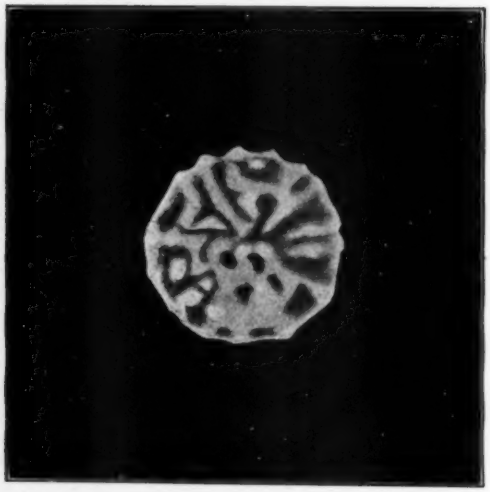

FIG. 8. STRUCTURE LINES IN CRYSTALLINE LENS.

seen with ease by the methods commonly explained in books upon experimental psychology.

If white rays may be seen around a white star on a dark background, then black rays must be visible around a black spot on a white background. They may be easily seen by screening the greater part of the pupil and allowing light from a black spot to pass through its margin. This is best done by a small circular screen on the point of a needle. By slight perseverance all the principal rays seen on a star may be perceived on the black spot. These are always present in the eye, but are not commonly perceived, because they are drowned out in the lighter background, and habit compels us to disregard them. Their importance in astronomical work is at once evident when I state that with the head in a definite position, I found it easier to see certain lines on the planet Mars and those easier lines coincided in direction with the two black rays represented in Fig. 9. It is evident that observations made with the greatest possible care ought to show these canals like marks, and if two of these rays be parallel, as may easily happen in an astigmatic eye, some of the canals should appear double.

FIG. 9. RAYS ON A BLACK SPOT OBTAINED BY SCREENING ALL THE PUPIL EXCEPT THE MARGIN OF THE (LEFT) SIDE. These rays are the two long rays on the left in Fig. 7.

Irradiation.—Next to the black rays in importance is the matter of irradiation as analyzed by means of ray forms. The method of investigation is as follows: Make a small hole in a window blind and observe the sky through it by different distances. From near-by the outline of the hole is well perceived, but, as one draws away, the rays soon obscure the hole itself, so that its form and size can not be perceived. At these different distances, the width of the rays varies with the true angular size of the hole. For example, I found at ten feet an irradiation of 2′ and at three feet an irradiation of 6′, because at the nearer point the rays are three times as wide and overlap each other at three times the distance from the hole. Irradiation then is the merging together of the rays, and on any straight line of separation, is proportional to the total ray light on the corresponding hemisphere about a star.

Color, size, intensity and perfection of eye are positive factors in irradiation. The negative factor is the background, and the result depends upon the sensitiveness of the eye at the time of observation. Some general results we can see at once. Irradiation is not necessarily the same in any two eyes or in any two directions. It varies with fatigue of the retina and probably with use of the eye in some unusual position, producing unusual conditions of pressure upon the eye-ball. Ordinarily, its amount depends directly on contrast between the areas observed and on the size of the central nucleus of rays in the desired direction. This nucleus must not be assumed to be centrally located on its source.

Best Part of Lens.—A very important bit of information derived in this study of the rays is the location and size of the best part of the crystalline lens. This is done by trying smaller and smaller diaphragms over the eye until the rays cease to appear. They will be found to persist in rudimentary form even when the diaphragm is as small as 1/16 of an inch. This is of great significance in telescopic and microscopic work, because it shows how small the emergent pencil of light must be to avoid the excessive formation of rays. Even at best, they can not be hindered entirely. The use of lower powers with large emergent pencil is therefore very dangerous. The optically superior part of the lens occupies a small irregular area near the center with irregular extensions out toward the margin. Even the best part is far from perfect.

Detached Spots.—An interesting variation of stellar rays has been observed at least in one case. A gentleman drew for me the rays as they appeared to his eye in the experiment described above (see Fig. 7), and while working asked me if I had placed a number of smaller pin holes around the large one. Fig. 10 represents this. It is perfectly possible for detached spots of this kind to be produced by some

irregularity of the lens structure and thus to supply illusive satellites to planets or fictitious companions to double stars.

Chromatic Rings

The illusive chromatic rings which follow do not bear so much on questions of Martian topography as the preceding halo and rays. Yet they are interesting of themselves and have an influence on color estimations. The first is the broad prismatic ring which extends from about 3½° to 5° from the source of light with red on the outside and green or blue on the inside. This shows well on any brilliant light such as the full moon or a bright electric light.

Fig. 10. Rays and Detached Spots.

The second is a narrow blue ring, of interest on account of its beauty. It is best seen on an electric arc light of intense blue color—and the less continuous spectrum the light shows, the better. Standing at a distance of one hundred and fifty or two hundred feet, one may see a beautiful narrow blue line forming a circle fully two feet in diameter about the light. As the color of the light changes to yellow, which it frequently does, the ring rapidly disappears into the center of the light.

This ring may be seen in the laboratory by passing the blue light of the spectrum through a pin hole. In mid-blue its radius is about 12′. Various experiments show that this illusion is produced at the margin of the pupil by the bending of the blue rays too sharply toward the optical axis of the eye. These rays therefore focus in front of the retina and on reaching it form a blue ring outside of the true image.

Radiating Lines from Near the Center of a Blank Disk

The only remaining illusion to which I call attention is one of much importance in planetary work, but one for which I shall not attempt an explanation. Frequently in observing a blank white disk, lines have appeared to me to radiate from some point near the center. When first I observed lines of that character, not knowing whether they were really there or not, I considered them genuine and for a long time represented them in the form of a star with four or eight

rays. At last when they did not show agreement among themselves I concluded they must be illusions. This was verified by specific trial, proving that such lines appear on perfectly blank areas. The rays so observed are sometimes double.

Application of these Phenomena

Against the obstacles of bad atmosphere, minuteness of detail and faintness, the observer has to wage a hard fight, and it is a matter of congratulation that he sees such faint canal-like marks on the very limit of vision. With full records the public may then discuss the interpretation.

The ray illusion is to me a very satisfactory explanation of many faint canals radiating from those small spots on Mars, called 'lakes' or 'oases.' The only objective reality in such cases is the spot from which they start. The reader will notice that rays on opposite sides of a star are usually in line. So when two lakes or oases lie along such a line they will appear connected by a canal. Nor do the oases need to be very close together. A ray 16′ long to the naked eye appears 4″ long on a planet magnified 240 diameters. With the planet Mars 16″ in diameter the ray then extends one fourth across it. It appears like a canal over one thousand miles long.

I believe the industrious observer has found and will find it difficult to avoid instinctively placing his head in a position favorable to producing combinations of this kind. After he has laboriously memorized the leading details, so that he may recognize what he sees, when, for an instant, Heaven vouchsafes him a brief view, he naturally has a powerful inclination always to observe in the same posture, for he finds that with a slight movement of his head his structure of fainter canals is liable to disorganization. This insistence upon the same attitude is at once understood when we consider a larger part of the faint canals to be due to rays in the eye.

We have here the medicine to prevent this disease in the future. Let the observer constantly vary the position of the head. As soon as the seeing becomes sufficiently good to reveal fine detail, let the movement of the head begin. A rotation through an arc of twenty or thirty degrees ought to be large enough to test thoroughly any fancied combination of canals. Drawings carefully made in this way will have one source of error eliminated.

The halo with its light area and secondary image accounts for details which have no objective reality, such as bright limbs of definite width, canals paralleling the limb or dark areas, numerous light margins along dark areas and light areas in the midst of dark—abundantly exemplified in Schiaparelli's map of 1881–2.

When a ribbon-like mark has sufficient width, it must appear

double; for the positive secondary image of the adjacent light areas will appear within it. To this end its apparent width to the naked eye must be some 8′ or 10′ (if eyes are alike in this dimension). In a telescope magnifying, say, 400 diameters, this width need be only a little over 1″. If the planet is 16″ in diameter (a rough average of its favorable position in recent years) this will amount to closely 10° on its surface. Now the double canals of Schiaparelli, in 1881–2, and of Perrotin and Thallon, in 1886, are frankly of this width and, I believe, are due to this cause. In any case the test to be applied is evidently the relation between the apparent width of a double and the radius of the halo illusion. The prevention of error in the future will evidently be the application of different powers to each canal, particularly a low power which will make its width appear less than 6′. This must be done with care for low powers increase the number of rays.

The halo illusion is also responsible for marginal canals. When a dark area becomes 6′ or 8′ wide, it appears double, having a light interior and dark edges. With any increase of width the dark edges, giving the effect of the marginal canals, remain. Hence along the edge of any dark area there appears a fictitious canal. Professor E. W. Maunder observed this in his excellent artificial planet study of a few years ago. I believe that high powers by reducing contrast will help to eliminate this error.

The mention of the chromatic rings draws attention to chromatic aberration in the eye and in the telescope. This effect in the telescope is so great that colors in a refracting telescope are not in the least trustworthy. The blue-green tint attributed to the dark areas on Mars is a product of the telescope. Its existence on our neighbor can only be verified by the use of a reflector.

Thus in conclusion we see that there are fundamental defects in the human eye producing faint canal illusions, that these have worked serious injury to our observations in the past and that in the future they may be avoided chiefly by the simple expedients of varying the position of the head and using a wide range of magnifying power.

THE PROGRESS OF SCIENCE

BERTHELOT AND MOISSAN

In the deaths of Berthelot and Moissan, France has lost its most illustrious chemists and the world two of its leading men of science. At the celebration held at the Sorbonne in 1901 in honor of the jubilee of the scientific work of Berthelot, Moissan said in his address: "As soon as you touch a question you extend it by generalizing it." The two great chemists indeed typify the changing conditions of scientific performance and of the scientific career. The more than a thousand publications of Berthelot cover a great part of the field of chemistry ranging from minute researches to the widest generalizations. He was a historian, an archeologist, a man of letters, an educational administrator and a statesman as well as a chemist. Moissan, on the other hand, obtained eminence by methods which it appears must become more common with the increasing specialization of science—intensive work in a comparatively narrow field.

Marcelin Pierre Eugène Berthelot was born eighty years ago, the son of a physician. His first scientific work, published in 1850, was on a method of liquefying gases. His thesis for the doctorate was on glycerine and the fats, opening up important questions in organic chemistry, which he followed by his work in synthesizing fundamental organic compounds, such as alcohol, acetylene and benzene. Berthelot then spent fifteen years attempting to lay the foundation of chemical mechanics by a study of the heat changes involved in chemical reactions. While all his principles have not been accepted, this work is one of the most important in the history of chemistry, both as regards detailed discoveries and broad generalizations. One of its incidental results was his study of explosives and the theory of explosion. Berthelot next turned his

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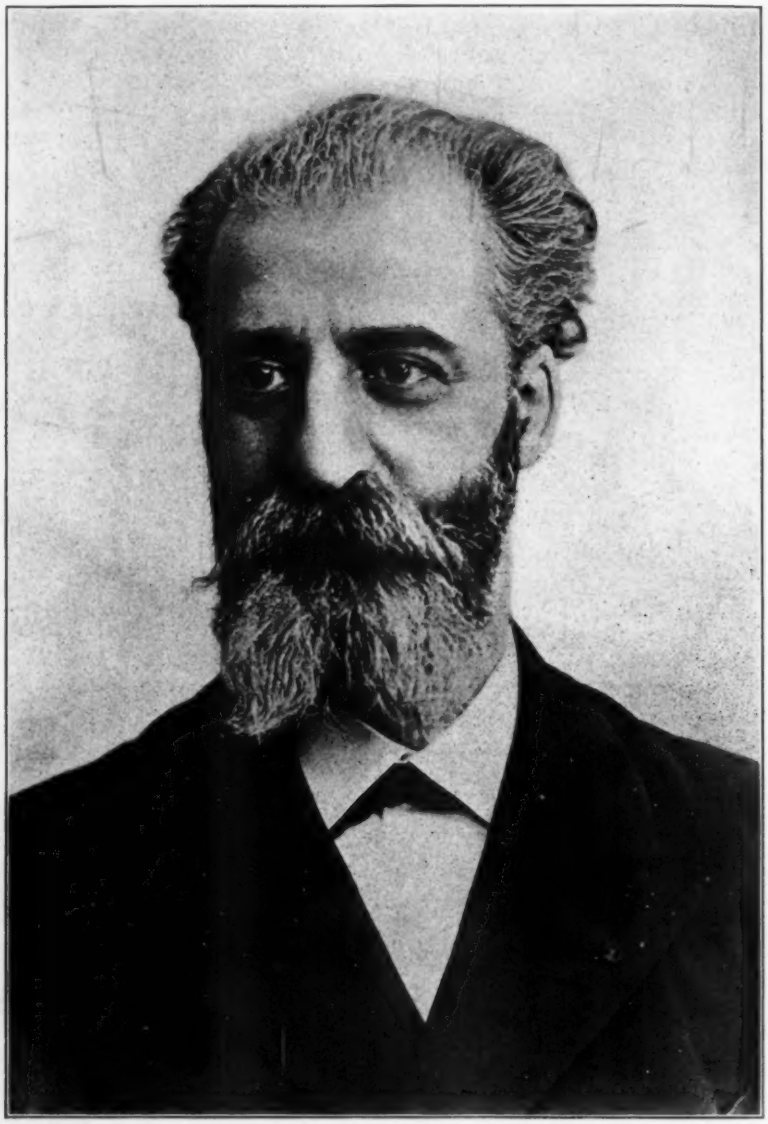


HENRI MOISSAN

attention to problems of vegetable chemistry, discovering the methods by which free nitrogen can be fixed under the influence of electrical discharge and the part played by the microbes of the soil in the fixation of nitrogen. For these researches a laboratory was built for him at Meudon. At the same time Berthelot published a series of important works on the history of chemistry and of alchemy, showing wide scholarship and archeological research. He also published a series of works on the philosophy of science, of ethics and of education.

Berthelot was active in public af-

fairs. During the siege of Paris he was president of the committee on defense, in 1876 he was appointed inspector general of higher education and in 1881 he was made a life senator. He was for a time minister of public instruction and later minister of foreign affairs. He was for many years permanent secretary of the Paris Academy of Sciences and was a member of the French Academy.

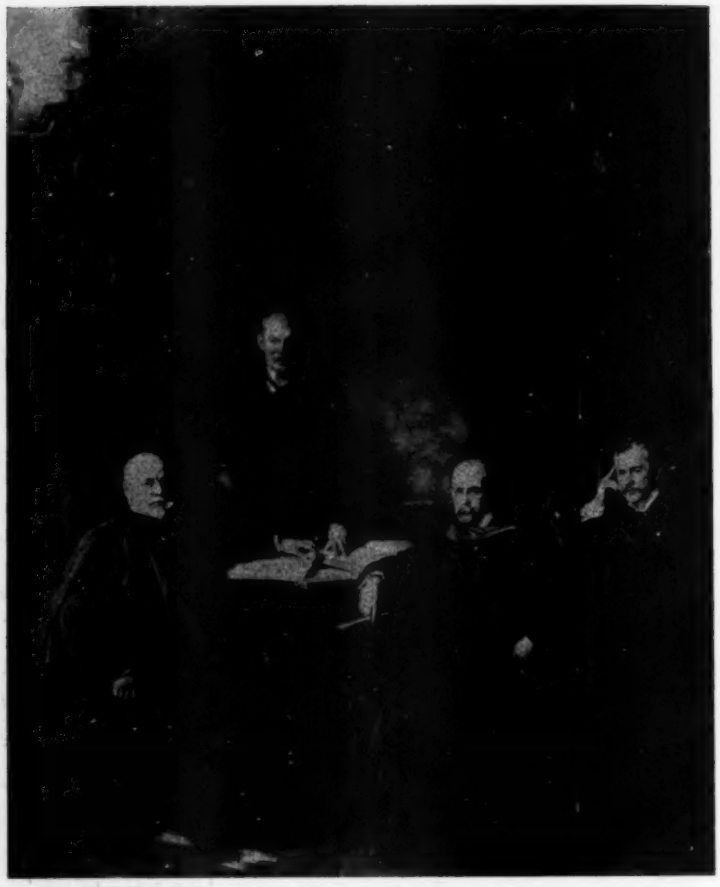
Returning from a meeting of the academy, Berthelot survived the shock of his wife's death by only a few minutes. The public funeral voted by the parliament before its adjournment as a mark of respect, the ceremonies of the national funeral at the Panthéon and the closing of all schools in France demonstrate in how high honor the French people hold their eminent men of science.

Henri Moissan was born in 1852, and his first work, published in 1874, was concerned with the absorption of oxygen and the emission of carbonic acid by plants kept in a darkened room. In 1880 he received the doctorate of science for work on the oxides of the metals of the iron group. He became eminent for his work on the isolation of fluorine, which he communicated to the Paris Academy in 1886, and which was followed by important researches on the chemical and physical properties of fluorine and its compounds. Subsequently Moissan took up the subject of high temperature researches, and became popularly known for the artificial production of diamonds. In his work with the electric furnace, Moissan investigated in detail a number of individual chemical reactions, including the formation of calcium carbide, which have been of great importance for the progress of inorganic chemistry. Moissan was elected a member of the Academy of Sciences in 1891, and, after teaching in the École supérieure de Pharmacie, became professor of inorganic chemistry at the Sorbonne in 1900.

THE FOUNDERS OF THE MEDICAL DEPARTMENT OF THE JOHNS HOPKINS UNIVERSITY

THE portrait group of Drs. Halstead, Kelly, Osler and Welch of the medical department of the Johns Hopkins University, painted by Mr. John S. Sargent, and here reproduced, has now been brought to the country and formally presented to the university by Miss Garrett. The painting is highly esteemed as a work of art, the critic of the London *Times* holding that it will do more to perpetuate the names of the subjects than their scientific achievements. However this may be, the work of these men and their associates, whether recognized or not, is and will remain an important part of the foundation of higher education in the United States.

When the Johns Hopkins University was opened in 1876, it set new standards of university work. For the first time in this country graduate work, research and publication were given their proper place. The men who taught and advanced knowledge and the men who advanced knowledge as they learned were the university rather than the buildings and equipment. The establishment of the medical department in 1893 did for medical education and for professional education what the university had done earlier for graduate work. Here for the first time to the fullest degree were united broad culture, expert training and research work. In some ways the achievement of the medical department has been even more notable than the earlier performance of the graduate department. In 1876 the time was ripe for a university, and a considerable endowment was available at Baltimore free from conditions. In 1893 a broadening of the medical curriculum was evidently needed, but the Johns Hopkins had less means than the other institutions. It accomplished what it did by bringing together a group of men notable for



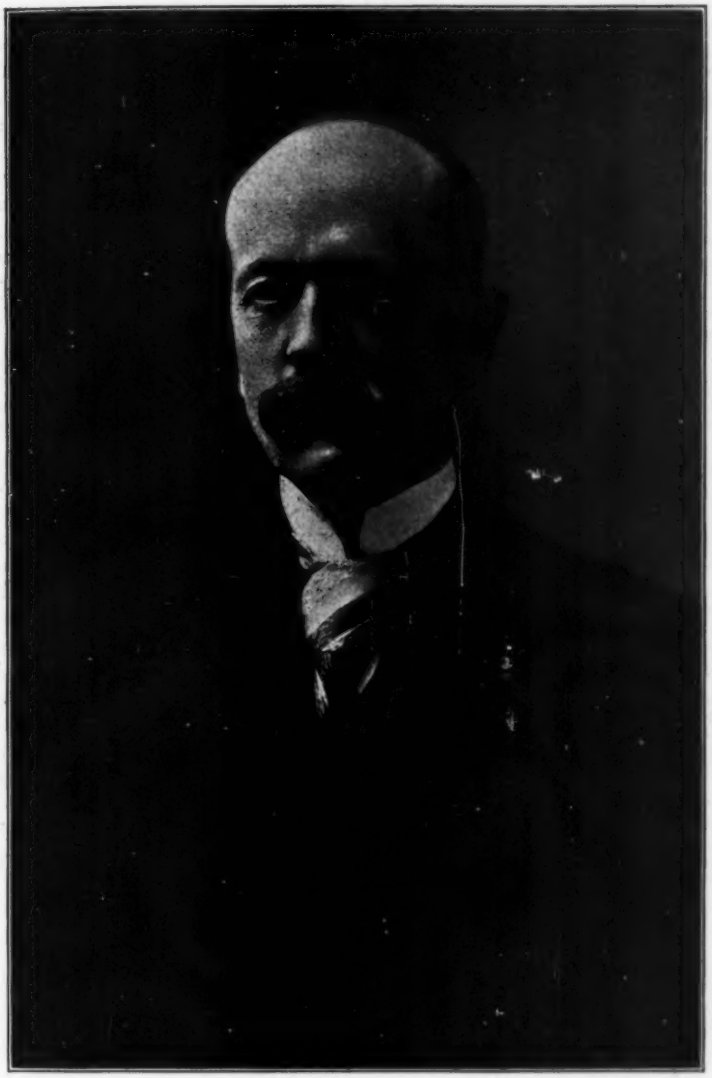
PORTRAIT GROUP OF DRS. HALSTEAD, KELLY, OSLER AND WELCH, OF THE MEDICAL DEPARTMENT OF THE JOHNS HOPKINS UNIVERSITY.

broad culture, professional skill and scientific research, and their spirit and example has made the medical department of the Johns Hopkins University a model of what a medical school should be.

THE DIRECTORSHIP OF THE U. S. GEOLOGICAL SURVEY

DR. GEORGE OTIS SMITH has been appointed director of the U. S. Geological Survey to fill the vacancy caused by the election of Dr. Charles D. Walcott to the secretaryship of the Smithsonian Institution. Dr. Smith received the bachelor of arts degree from Colby College in 1893, and the doctorate of philosophy from the Johns Hopkins University in 1896, in which year he was appointed assistant geologist to the Geological Survey, being made geologist in 1901. He has had charge of the geological work in New England and of work in petrology.

The work of the survey has developed with remarkable rapidity under the direction of Dr. Walcott, the appropriation for the current year being in the neighborhood of a million and a half dollars, and the directorship of the survey having become one of the most important and influential



DR. CHARLES D. WALCOTT
SECRETARY OF THE SMITHSONIAN INSTITUTION

scientific offices in the country. On March 13, the retiring director was entertained at a banquet by his colleagues, which was attended by some two hundred and fifty members of the survey, and their guests. Colonel H. C. Rizer, chief clerk, presided, and addresses were made by representatives of the different departments of work: Mr. Bailey Willis spoke for the geologic branch, Mr. W. M. Beaman for the topographic branch, Mr. M. O. Leighton for the water resources branch, Mr. S. J. Kübel for the division of engraving, and Mr. F. H. Newell for the reclamation service. Dr. Charles B. Dudley spoke of the fuel-testing work of the Geological

Survey. A letter from Mr. Arnold Hague was read, as also a telegram from Mr. Henry Gannett. Mr. Gifford Pinchot paid a tribute to Mr. Walcott in relation to the forestry work of the government. The closing address was by the Hon. James R. Garfield, secretary of the interior.

SCIENTIFIC ITEMS

WE regret to record the deaths of Professor W. H. Bakhus-Rooseboom, professor of physical chemistry at Amsterdam; of M. Marcel Bertrand, professor of geology in the Paris School of Mines, and of Professor Ernst von Bergmann, the distinguished German surgeon.

LORD LISTER celebrated his eightieth birthday on April 4, on which occasion it was announced that a collected edition of his scientific papers would be published.—The London Society of Dyes and Colors has founded in honor of Sir William Perkin a Perkin medal to be conferred for scientific and industrial work connected with the dyeing industries.—Professor George T. Ladd, who recently retired from the active duties of the chair of philosophy at Yale University, has gone from Japan to Korea, at the invitation of Marquis Ito, in the interest of the educational development of the country.—The Prussian ministry of education has appointed Professor Felix Adler as Theodore Roosevelt professor in the University of Berlin for the year 1908–09, upon the nomination of the trustees of Columbia University, where he holds the chair of political and social ethics.

THE new buildings of the Carnegie Institute at Pittsburg were dedicated with imposing ceremonies on April 11, in the presence of a large number of invited guests from Europe and the United States. The ceremonies were extended through three days. Previous to the dedication it was announced that Mr. Carnegie had given $6,000,000—four million to be added to its endowment and two million for the Technical Schools, half for further buildings and half for endowment.

AT the meeting of the Association of American Agricultural Colleges and Experiment Stations at Baton Rouge last November a resolution was adopted instructing the incoming president of the association to appoint a commission of five persons to inquire into and report to the association on the organization and policy that should prevail in the expenditure of public money provided for experimentation and research in agriculture. The president of the association, Dean L. H. Bailey, of Cornell University, has appointed the following commission, the first two representing persons outside agricultural investigations, the second two representing the association, and the last representing the Department of Agriculture: David Starr Jordan, president of Leland Stanford University, *chairman;* Carroll D. Wright, president of Clark College; H. P. Armsby, director of the Pennsylvania State College Agricultural Experiment Station; W. H. Jordan, director of the New York State Experiment Station; Gifford Pinchot, forester, U. S. Department of Agriculture.